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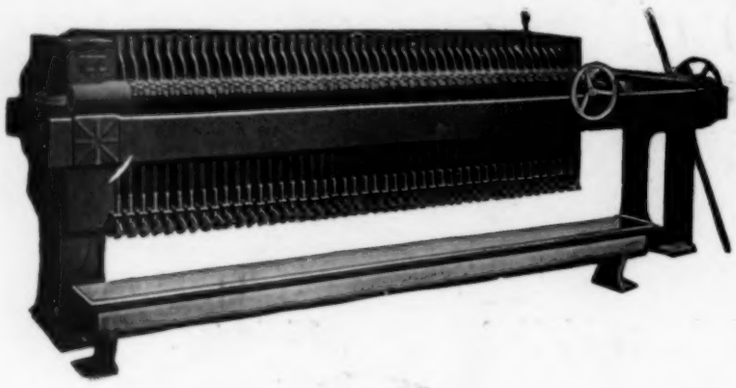

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A British View Of the Dye Industry

IT IS REFRESHING to observe the wholesome respect with which the policies of leaders in industry are being received. An industrial program based on strict observance of the principles of sound economics which a short time ago was a voice crying in the wilderness is now hailed as a master stroke in the "return to normalcy." Fable has it that it took the fall of an apple to demonstrate to NEWTON the truth of the law of gravitation. Evidently it has taken the collapse of the bubble of post-war prosperity to bring home to our industries the existence and operation of economic laws which had been lost sight of in the period of speculation and overexpansion during and immediately after the war.

Some industrial problems are local and some are worldwide. Those confronting Great Britain are similar to our own, although perhaps more serious in many cases. Railroad and freight rates are higher than they should be. The coal production is uncertain and prices for home consumption are variable. The labor situation is unsettled. The dye and chemical industries are threatened, but they have an able champion.

"Chemicals and dyestuffs form the two most important and valuable key industries that a nation can possess. They ought to be vigorously developed and closely guarded." Thus spoke Sir WILLIAM ALEXANDER, chairman of the British Dyestuffs Corporation, Ltd., in a statement given to *Chemical Age* (London), after an extended tour of the United States and Canada in the interests of the future of the British dye industry. He points out that Great Britain has facilities in modern equipment for supplying at least the requirements of the British Empire. These new and extended installations should not be permitted to become derelict, for they stand for national security as well as commercial prosperity. They can be maintained in operation if British consumers will support British industries, if British chemists and engineers will concentrate on obtaining maximum efficiency in their plants, if labor will recognize that maximum production is its best security for good wages, if the British Government will continue to assist the industries to fight against depreciated currencies and other handicaps to fair trading and if the government will send commercially competent consuls and trade commissioners to pioneer and assist in the development of British trade. The reconstruction of Europe is all-important to Great Britain as an exporting nation and Sir WILLIAM advocates the rendering of aid by solvent countries to assist in reconstruction on sound lines, but warns against trade with nations on hazardous credit.

Such a reconstruction policy is sound economics and applies equally well to the United States. The depreciated currency and phantom credit of insolvent nations should turn the body of trade of exporting countries within their own boundaries, thus insuring maintenance of production facilities and a circulation of money within the country—a condition which stimulates production and employment. Nations whose currencies have fallen so low as to have little or no purchasing power must suffer until they have reorganized their internal economies and industries by production so that exports may balance imports. Production is their salvation, and the sooner such reorganization is accomplished the sooner will those countries reach a stable economic condition. But for countries like Great Britain and the United States, which have balanced budgets and fairly stable business conditions, the great desideratum is the maintenance of those key industries like dyes and chemicals which have been built up at great cost under arduous conditions. We wish political leaders could see the light as clearly as business men.

In Full For Services Rendered

OUR comment last week on the soldier bonus has brought some friendly protest from subscribers who are members of the American Legion and favorable to bonus legislation. We did not expect that our opposition would meet with unqualified universal approval, but we felt that it was in the best interest of business and industry to sound a warning against increasing taxes at a time when the nation is already heavily in debt and its citizens are struggling under a burden of unprecedented magnitude.

There is no doubt in our mind that the country, as a whole, does not want bonus legislation. It is noteworthy that no public voice other than that of politicians and American Legion officers has been raised in its support. As far as we are aware, every newspaper of importance has expressed itself editorially against the proposal. The all-important question is, Where is the money coming from? We think it not unfair to call upon the American Legion to make some constructive suggestions in the solution of this problem. It is unfair to sidestep it. In trying to solve it, Congress is in the most desperate dilemma with which it has yet been confronted. Will the Legion openly sponsor additional taxes in any form: a sales tax, a stamp tax, a motor tax, a gasoline tax, new taxes on tobacco, postage and theater tickets? Will it advocate these things or any of them to the farmer, the small merchant or the salaried man? If it will undertake something definite of this kind, we believe it will soon discover just how unpopular the bonus measure is.

Elsewhere we publish a few letters inspired by our editorial comment of last week. One of our correspondents unfortunately argues for the bonus on the basis of "paying a debt to those who 'took a chance' against the German" and "sufficient recompense for the time

spent on military duty." The argument does not appeal to us, nor do we think it is the best that can be advanced. Will the American Legion, or any member of it, or our correspondent give a receipt to the United States "in full for services rendered," and acknowledge that he has been fully compensated by the payment of a sum ranging from $500 to $625? We think not. We hope not. No cash value can be placed upon the service rendered by those who wore the uniform in the late war, whether they helped build Muscle Shoals or fought their way through the Argonne.

It may be just as well to mention the fact that in opposing the soldier bonus we are not expressing the opinions of theorists. We speak as those having experience, if not authority. Five men on CHEM. & MET.'S staff served overseas and in this country. They came out of the war poorer than they went in. In no case did their war-time compensation amount to enough to take care of themselves and families and they were obliged to draw upon savings or to incur debt. But none of them is in favor of the bonus. They all realize that legislation for it would be an economic blunder.

Mysticism Among Men of Science

IT WAS NOT so very many years ago when most men of science were in open conflict with all that is mystic in life. We older fellows called it the conflict between Science and Religion—and so did Dr. DRAPER and so did Dr. WHITE of Cornell. It was a lively and rather bitter quarrel in which nearly everybody took side. The fight was hot and anger was rife, so that very few of the parties of either part could see that the dispute was not between science and religion, but rather between science and dogma.

It appears to us that a turn in the habits of thought of many men of science is coming about. They are not seeking the mourners' bench or weeping over their sins or singing revival hymns or even growing orthodox from the standpoint of dogma; but there appears to be coming over a considerable number of leading men of science an enlivened reverence for that which is beyond human knowledge. It shows itself in various ways. Sir WILLIAM CROOKES did, and Sir OLIVER LODGE does, believe in ghosts. They have not many followers among their colleagues. The tendency is rather toward a less definite quality of mysticism; toward a belief in a greater illumination than is ours. It is not organized and it does not follow creeds or catechisms or articles that were drawn and recorded when, according to the best human understanding, the earth was flat like a cake, when it was the center of the universe, when the sun was a great lamp that was raised in the morning and lowered at night, and the lesser lights, the moon and stars, were little incidents to mitigate the darkness.

Earlier generations accepted orthodoxy. Sir ISAAC NEWTON was a man of unusual piety. MICHAEL FARADAY was a sound churchman. LOUIS PASTEUR was among the last of the great men of science to whom the "requirements of faith" were welcome.

The present tendency is independent of dogma. It does not insist on any particulars. It does not condemn. It seeks the Greater Illumination and finds hope and comfort in the quest.

On January 8 last Professor MICHAEL I. PUPIN of Columbia made a memorial address at St. Paul's Chapel on the campus in honor of those who in their lifetime had advanced the honor of Columbia University. Now to such persons as know him casually, the genial professor of electromechanics would be about the last one they would expect to see in a pulpit preaching a sermon. But his beautiful "Herdsman's View of Human Life" was indeed a sermon. He harked back to the time when, 50 years ago, he had helped the village herdsman to guard the grazing oxen through the night on the hills of Serbia. The mystic thoughts of ancient reverence that inspired the watching boy have not been killed by the study of science. It was beautiful and reverent and sincere, and it did not offend the understanding. Many will remember the plea for spiritual vision made by Professor BASKERVILLE in his address at the Great Hall of City College during the September joint meeting of the chemical societies. It was his last public utterance, this urgent appeal for the search after light to come from beyond our ken. Dr. CHARLES P. STEINMETZ in his illuminating contribution to the current number of *Harper's Magazine* has approached close to the boundaries of mysticism.

It is an excellent thing to "get down to brass tacks" in our discussions of particular things and in the consideration of principles and processes. But the world is not made up of brass tacks alone. There are vague shapes in the minds of men and women that are potent to build up or to destroy. As men of science we are beginning to see that our obligations extend far and away beyond the laboratory, and that, among other things, the duty is ours to guide the vague shapes into the paths that lead to human welfare and betterment. We, too, are our brother's keepers.

X-Ray for Routine Testing

EVEN the best modern testing laboratories seldom possess X-ray apparatus, and it is still more rarely seen in use for the routine examination of chemical and metallurgical materials. But for that matter, only a few years ago a microscope was nothing but an instrument for advanced specialists, and the old ones among us can even remember the introduction of the analytical balances. So it is somewhat unsafe to prophesy the future utility of recently discovered and adapted implements of research when applied to the multifarious needs of present-day industry.

But based on past performances, some of which are well known, and on recent developments, not so widely advertised, the X-ray seems likely to become very useful in three major directions: First, for revealing sizable internal defects; second, for studies in crystallography; third, for spectrum analysis.

The first kind of work is an extension of the methods and equipment commonly used by dentists and medical men when they make shadowgraphs to aid in their diagnoses. A pencil of rays is passed through the body to be examined; the denser portions absorb or scatter a greater proportion, and cast a "shadow" on a fluorescent screen or photographic film placed beyond. In this way internal defects in solid material, improper material covered by veneer or contained in solid packages, and poor fits at joints can be easily determined in suspected articles, without destroying or even disturbing them in the investigation.

Notwithstanding the fact that such methods are thoroughly practicable for organic substances, they will require much development before they will be extensively used for testing metal. As a piece of steel becomes greater than 1 in. thick, the time of exposure

increases rapidly and the indications rapidly become less distinct. Of course, it is easily possible that the sensitivity of the fiber may be increased, some method of filtering out the confused beams scattered by the metal itself may be devised, and Coolidge tubes of very high power might be constructed. But even so, the physical danger attending the use of such penetrating rays and the enormous difficulties to be overcome at present seem to limit the use of pure radiography to moderate sections of metals of low atomic weight. Exposures of such castings, for instance, should show the presence or absence of dangerous blowholes or slag inclusions quite clearly. Unfortunately their cracks cannot be found unless placed "edge on" to the rays.

Crystallography is a subject which the ordinary testing engineer would associate with geology or mineralogy, and therefore quite anterior to the testing of materials in process. However, X-ray crystal analysis may easily become of great value in working with graphite, clay and various other substances entering largely into present-day industry but about whose chemistry and physics we are so relatively ignorant. A compact machine has recently been described in these columns for crystal analysis, and Dr. BAIN has shown how it has already yielded results of the greatest importance to theoretical metallurgy. Briefly, the method consists of passing a monochromatic ray through a sample of powder or fine-grained solid. The ray is photographed after reflection from the variously oriented crystalline planes. This reflection occurs in certain dominant directions which depend upon the atomic arrangement and which can be computed for the various crystal systems. Since no two substances have the same crystal structure, here is a new method of analysis. Unfortunately, it is not yet capable of showing small traces of adulterants. However, many substances of identical chemical composition exhibit isomerism and allotropy. Such a substance will exhibit many puzzling variations in its properties and action when in process, and yet the reason will of course be undiscoverable by chemistry and often elude other physical investigations.

True X-ray spectrum analysis may become more popular than the older visible spectrum analysis, because the number of X-ray waves characteristic of each element are very small and can be easily recognized. Furthermore, the intensity of the lines is strictly proportional to the amount of the element present. When practicable, the material to be investigated is rubbed into the face of the target in a Coolidge tube. X-rays emitted from this target are then analyzed by the X-ray crystal spectrometer, and the result compared with the radiations from the standard material—where only a comparative test is to be made—or to the characteristic waves for the various chemical elements, when an ultimate analysis is desired. Much the same results may be had by passing a pencil of X-rays from a tungsten target through a sample, and analyzing the emergent rays for absorption bands. This practice is particularly sensitive in detecting very small traces of heavy elements occurring in materials of low atomic weight.

Enough has been said in the above brief outline, however, to indicate that unquestionably the X-ray is a powerful tool, whose ultimate development and application cannot now be foreseen. Enthusiastic men in many laboratories will doubtless seize upon it now that the equipment has become available in compact and simple form, and adapt it to their own uses. What they will be able to do will be awaited with great interest.

Profits and Losses
In the Steel Industry

THE "prince or pauper" industry experiences great vicissitudes in the matter of profits and losses, not simply because the demand for its product varies widely but also because it is subject to heavy overhead or fixed expense. The capital invested in facilities, excluding transportation facilities but including ore mines, coke works, blast furnaces, steel mills and finishing departments, is not far from $100 per gross ton of annual output in finished steel when there is substantially a capacity operation, so that there is an interest charge alone of something like $10 per ton on a 50 per cent operation. Then there are general administrative and selling expenses as well as a heavy expense in those employees at manufacturing plants who are naturally carried on annual salaries and whose employment does not vary according to tonnage output. Another fixed expense is taxes. This item cannot be estimated closely, but it is a matter of record that the United States Steel Corporation's taxes in 1920, exclusive of federal taxes, amounted to $38,724,289, the output of steel products for sale being 14,228,502 tons, representing an operation at 88.3 per cent of capacity. Allowing that part of the taxes accrued on transportation and other properties not engaged directly in steel manufacture, the direct taxes would be close to $2 a ton on a full operation, or twice as much per ton on a 50 per cent operation.

Given competitive conditions in the steel market, the free play of the law of supply and demand, with a demand less than 50 per cent of capacity, it is easy to see how the steel industry can quickly develop a condition of selling its product at a loss. The cost per ton mounts and it would require a high selling price to enable all producers merely to break even.

There were very few independent steel companies that did not report losses in 1921 and some of the losses appeared very large. The United States Steel Corporation reported earnings in both the third and fourth quarters of the year sufficient to pay all charges together with the preferred dividend, but with scarcely anything left for the common shares, on which the dividend at the modest rate of 5 per cent a year was maintained chiefly by drafts upon surplus.

A common view is that the Steel Corporation has such refinements and economies in operation that it can make profits when independent companies have losses, given similar conditions as to selling prices and rate of operation. This may be true, but the financial reports published do not prove the point, because conditions as to selling prices and rates of operation were not identical.

Even the Steel Corporation, however, is in a tight place as regards earnings. Superficially, the corporation seems to have done well when it reported earnings at $18,918,058 for the third quarter of 1921 and $19,612,033 for the fourth quarter, representing an increase of 3.7 per cent; but the showing is not as good as appears, since the earnings per ton greatly decreased, there having been an increase of 50 or 60 per cent in shipments from the third to the fourth quarter. Furthermore, the December shipments were at approximately the average rate for the quarter, while the December earnings were only $4,967,237, or at the rate of less than $15,000,000 for a quarter, instead of $19,612,033. Realized prices are probably running a trifle lower now than in December, while production is improved but little if any.

Readers' Views and Comments

Does Business Want the Soldier Bonus?

To the Editor of Chemical & Metallurgical Engineering

SIR:—I am not in the habit of writing with reference to editorials but I do wish to say that I feel a large percentage of the thinking men of the country are heartily in accord with the attitude which you have taken on the soldiers' bonus. I wish to extend to you my congratulations that you have the nerve to publish an article of this character.

At present I have in my department a few men who have been overseas, one of whom has suffered the loss of one arm. I think I am safe in saying that every one of these men who has seen actual service takes essentially the same attitude that you have in your editorial. I am speaking advisedly in this matter, because one of the strongest men in our school happens to be my personal assistant, an overseas man, who feels very strongly as you do, and knows the attitude of the other overseas men who are worth while.

Chemical Engineering Dept.,
Bucknell University,
Lewisburg, Pa. GLENN V. BROWN.

To the Editor of Chemical & Metallurgical Engineering

SIR:—I am always glad to recognize the courage of those who express their opinions at a time when such a statement may detract from their popularity and add nothing to their bank account; however, I wish to express an opinion contrary to the stand you have taken regarding the soldier's bonus.

It is my belief that not all the opponents to this legislation are as sincere in the cry for economy and their fear of national bankruptcy as you are.

The ex-service men of your acquaintance may be possessed of a super-patriotism that is not evident in western Pennsylvania, for I have not met a man who thought he had received sufficient recompense for the time spent on military duty.

Some of our self-styled economists have pointed out the advantage of paying still larger amounts to the railroads and the cancellation of the foreign debt; but the paying of a debt to those who "took a chance" against the German goes against their theory of economics and their morals.

We ask no favors, no courtesy, no preference; but only fair pay for a job which others have said was well done.

G. W. PAULIN.
Leechburg, Pa.

To the Editor of Chemical & Metallurgical Engineering

SIR:—I was greatly disappointed with your editorial in the current issue on the soldiers' bonus. I am proud to be a member of the American Legion and do not appreciate the implied slur on it, for it is an organization actuated by the highest ideals and one which is pledged to promote the best interests of the country as a whole. At the present time it appears that it is only just that those who spent time in the service of the nation should have some form of compensation to place them on a financial par with those who for one reason or another did not go. Most of the influential members of the American Legion are agreed that the cash settlement plan will be chosen by only a small proportion of the total number of eligibles and by even a smaller ratio of our members. However, you should know that we are undertaking a census to determine that matter accurately.

Bonuses were given freely to those who might otherwise have lost by cancellation of war contracts, to the railroads and to the civilian employees of the government. We do not say that these were not necessary and just, but we do claim that compensation for the veterans is not only just but will be a good investment for the future economic welfare of the nation as a whole, for it is so designed as to throw by far the larger part of the amount allowed into the purchase of homes and farms, the two types of investment which do most to promote stability and industry in society.

As a chemical engineer and an old subscriber, I hated to see you misled on this very important question and hope that you will get in touch with our national officers and get a definite and accurate line on the Legion aspirations before writing your next article on this subject.

Kansas City, Mo. R. H. BAXTER.

Human Relations in Industry

To the Editor of Chemical & Metallurgical Engineering

SIR:—Referring to the subject of "Human Relations in Industry," considered by Dean Kimball in the Jan. 18 issue of your journal, may I offer the following suggestions?

Nothing more timely in the consideration of what should be included in "the content" of the courses given by our educational institutions can be suggested than that our educators dig hard and deep to find a permanent foundation for and build thereupon a constructive course in what I would term a Science of Human Relations. The subject is the very cornerstone among all the educational materials out of which the world's most helpful leaders among men should be technically, morally and spiritually constructed.

As Dean Kimball says, a sound philosophy of what human relations in industry should be has not as yet been formulated, but may it not also be said much, very much, more effort to do so than has been heretofore undertaken may be with correspondingly better understanding? As old as history are the records of man's efforts to find a system of moral direction suitable for all mankind, yet to this day unity of formula seems as far off as before; still such teachers are by their patience and conscientious zeal a great directing force in our civilization.

As engineers many of us are today more than ever impressed by such sayings as "Obligations and duties take precedence over rights and privileges," and again, "His kindliness, wisdom and humanity made him a natural leader." Great harm is too often done by sneering at this moral or ethical basis of any association as the aspiration of overpious and impractical minds, and it is an inspiration for those of us who believe otherwise to read Dean Kimball when he says, "A new industrial day has dawned . . . we are more interested in men than in machines."

These and many similar enunciations of principles

and policies surely are not fully amplified by a general advocacy of the Golden Rule. They are keys and by the synthetic investigation and study of the substance they represent, the first lines are found for a codification of a class of practical knowledge to which our schools and colleges might give more special attention, if not a curriculum status in their courses.

EDWARD F. WHITE,
Middleport, N. Y. Mechanical Engineer.

The Field for University Patents

To the Editor of Chemical & Metallurgical Engineering

SIR:—Dr. Hale's vigorous contribution to the discussion of university patents in your issue of Nov. 16, 1921, is convincing. One cannot disagree, granting his premises. But Dr. Hale has missed the point entirely. I am sure that Mr. Hoskins and Mr. Wiles were not thinking of the location of the eye in a needle as a "basic patent"; nor would it ever have occurred to them that a clutch release could possibly be the object of a university research. Admittedly, these are basic matters for the industries concerned, but from the scientific point of view the only proper results from university researches must be far more basic.

Roentgen's discovery of the X-ray was patentable. That is the sort of thing that universities are giving to the industries with no recompense. Faraday's fundamental work on electric current, Schömbein's discovery of ozone, Daguerre's application of the photo-sensitiveness of silver salts in photography, Millikan's determination of the properties of the electron—these are instances of what pure science has done for industry. And seldom has the scientist or his institution drawn any monetary reward.

Soon a university man will discover how atoms may be broken down into their constituent parts, and will release incalculable energy for human use. This is the sort of work the reward for which should go to the universities, and not to industry, nor primarily to the man who succeeds in it; and if such matters as these are considered instead of the instances which Dr. Hale gives, his arguments are pointless. Such discoveries should not be given outright to industries; neither could they be licensed to any one manufacturer, and no single professor could remain a research man if the administration of the patents were to be in his hands. The only solution which will endow research, reward the inventor, compensate the universities and place the tax where it is due and gladly payable is that suggested by Messrs. Hoskins and Wiles.

Finally, Dr. Hale's chief point is that no matter what the invention, the professor himself should maintain and defend the patent. Messrs. Hoskins and Wiles grant that the inventor has every right to do this, but they realize that the large majority of pure research men are what they are because they have no time for business and could not administer a patent if they would. Hence they suggest that the university provide a repository which will secure all previous benefits and in addition would prevent the scientist from interference by business detail with which he has no concern.

Chicago, Ill. GERALD L. WENDT.

To the Editor of Chemical & Metallurgical Engineering

SIR:—In commenting upon my contribution in your issue of Nov. 16, 1921, Dr. Wendt would have us believe that foundation researches are really patentable. We all agree at the outset that universities should in some way be able to reap rewards for the discoveries of those broader principles, so many of which in the past have fallen to the credit of university investigators. But have these discoveries been patentable in themselves alone? Certainly not. Were Dr. Wendt to apply for a patent on some such general discovery as he has mentioned, he would become painfully cognizant of the necessity of setting forth clearly and pointedly the actual claims in no vague terms, nor could his claims cover the entire field of human endeavor.

If Dr. Wendt will pursue the history of scientific theory, he will find that the possibility of obtaining patents in the name of the leading discoverers was practically reduced to nil in the face of diversified applications so speedily come upon by any number of enthusiasts. When the patent application does not embrace all of the possible claims known at the time, the patent carries little of actual value.

Let us take, for example, a case illustrative of this development from earliest record to final utility. The discovery by Maxwell, the theorist, in 1873, that light is an electric phenomenon could not have been patented, nor also his inference that there are other electromagnetic waves, non-illuminant in effect. Hertz, the research physicist, who in 1886 actually proved the existence of these other electromagnetic waves and described their properties of penetrability as regards solid walls, etc., had little to patent. But Marconi, who in 1896 was able to collect these waves by antennæ and record impulses therein by the flow of current through a coherer, actually hit upon the wireless telegraph, which cannot be construed otherwise than of a basic patentable nature. Now, Hertz deserves greatest praise for his researches, university researches as they were, but everyone knows that he did not have enough to make up a basic patent. Marconi's discoveries, therefore, will ever be regarded as of the basic patent class.

Those discoveries cited by Dr. Wendt were for the most part non-patentable, although they are of general import and certainly give credit to the universities where they were announced. After all, we must not overlook the fact that universities owe much to the industries for their lease on life and certainly these general contributions by universities to science will do much to stimulate further investigations for the good both of the universities and of the industries.

Patents should be obtained upon university researches as well as upon others. The chances for early patents, however, are more likely to fall to industrial research laboratories, where intensive work under high pressure may be instantly inaugurated. My contention has been and still is that the university is not organized to take over the ownership or control of patents and patent rights. In this I feel that university men are thoroughly in agreement, as vouchsafed by over fifty letters recently received by me in commenting upon the contribution of Nov. 16. Not one single case opposing the views therein set forth has come to my attention, save of course these comments of Dr. Wendt.

Let us not forget that university faculties are made up of intelligent men. Were I ever again to be holding a place of honor in a chemical faculty, I certainly would no more consent to have my prerogative as chemist interfered with than I would consent to the university's taking up and handling a case of divorce, assuming thereby that my duties and responsibility to the university as a chemist precluded the possibility of my being able to look after my own affairs.

Midland, Mich. WILLIAM J. HALE.

An Outline of the Uses of Lime*

Chemical Uses: Raw Material in the Manufacturing Industries; Sanitation; Purification of Materials; Food; Catalytic Processes; Utilization of Byproducts; General Utility; Miscellaneous—Construction Uses—Agricultural Uses—Chart Showing Some of the Many Functions and Uses of Lime

BY M. E. HOLMES, PH.D.
Manager, Chemical Department, National Lime Association

THE use of lime in mortar and plaster was, in past ages, its only important use. Coincident with our modern industrial development along technical lines, the lime industry has expanded enormously in the number of its technical uses and thereby has offered a fertile field for the activities of the investigator and writer. The "Uses of Lime" is the subject of a paper read in 1904 by S. V. Peppel[1] before the convention of the National Lime Manufacturers Association. Since then a number of publications have appeared. In 1913 the United States Geological Survey issued a publication on the "Sources, Manufacture and Use of Lime."[2] R. K. Meade[3] in 1914 wrote a paper on the "Composition, Manufacture, Properties and Uses of Lime" and at a later date[4] contributed an article on the "Valuation of Lime for Various Purposes." In 1920 the Bureau of Standards issued a publication[5] under the title "Lime, Its Properties and Uses."

In the present article the author has approached the subject primarily from the point of view of a systematic arrangement in outline form of the uses of lime, grouping the various uses under headings indicating functions performed by the lime. In order to show the unusually large number of functions that lime can perform, we have included not only the well-known uses that represent large tonnage but all the uses of which we have authentic records.

In order to give a proper perspective of the relative importance of the various uses, the latest available data compiled by the United States Geological Survey are rearranged and presented in Table I to show the tonnage distribution of lime by uses. These data are supplied to the Survey by lime manufacturers, who specify the uses for which their lime is sold. The data show that the largest single use of lime is for construction purposes, 1,305,412 tons being reported for 1920. This use is followed by paper mills, with 365,897 tons, agriculture with 351,851 tons, metallurgy with 344,921 tons and refractories with 316,293 tons. At this point there is a large drop to the next important use, which is that for making alkalis, which consumes 104,250 tons. Then follows a gradual decreasing series of figures for the lime consumption in the seventy itemized uses which follow. The item of "unspecified," representing 178,904 tons, accounts for the many other uses for which lime can be and is used. Although it is impracticable to include tonnage figures for the numerous small uses, yet they are important in considering possible future tonnage and in a study of the functional capacity of lime.

In industrial technology it is convenient to divide the uses of lime into three major groups—viz., construction uses, agricultural uses and chemical uses. The construction uses include those involved in building operations, the agricultural uses are limited to the uses on the farm, and the chemical uses include the very large number involved in manufacturing and technical processes. Although the allocation of certain uses is somewhat arbitrary, yet it serves to divide the field in accordance with the duties of the engineer, agronomist and chemist.

The Chemical Uses of Lime

Until recent years the use of lime in chemical engineering processes has been of negligible importance. The rise of the science of chemistry has been attended, however, by disclosures of numerous technical uses for lime which has opened up a new outlet for the industry of such magnitude that it may safely be stated that the chemical uses of lime are now the most numerous and most important in point of tonnage. Calculations from

TABLE I—DISTRIBUTION OF LIME BY USES

	1919	1920
Construction	1,191,434	1,305,412
Paper mills	335,813	365,897
Agriculture	438,632	351,851
Metallurgy	295,622	344,921
Refractories	222,036	316,293
Unspecified	119,770	178,904
Alkalis	136,896	104,250
Water purification	.....	90,533
Sanitation	82,522	(a)
Calcium carbide	140,165	88,465
Tanneries	59,978	61,162
Glass works	44,618	54,747
Acids	8,178	48,361
Bleaching works	27,804	24,030
Calcium acetate	(a)	22,241
Silica brick	16,552	20,371
Sand-lime brick	5,096	19,521
Soap manufacture	.....	18,607
Undistributed (*)	30,742	17,347
Coke and gas manufacture	17,207	.....
Sugar factories	13,111	14,145
Ammonia works	5,323	10,041
Coke-oven byproducts	.....	8,740
Explosives	7,196	(a)
Spraying	.....	6,141
Glue manufacture	4,499	5,641
Cyaniding	5,206	4,295
Oil, fat and soap manufacture	29,205	3,238
Corn products	(a)	2,428
Paint manufacture	2,275	1,954
Wood distillation	(a)	1,474
Sewage purification	.....	1,361
Gas plant byproducts	.....	1,207
Dairy products	(a)	1,207
Gelatine manufacture	.....	1,183
Coal and water gas purification	.....	1,164
Salt refining	(a)	921
Flour mills	350	313
Dininfectant	.....	205
Candles	.....	114

(a) Included under "Undistributed."
(*) Included in 1919: Lime used in the manufacture of calcium acetate, alcohol, phenol, salt, oxygen, corn products, rubber, textiles, baking powder, belting, lime pencils, dairy products, polishing and buffing compounds, distillation of wood; in 1920: Lime used in the manufacture of gypsum products, rubber, lubricating grease, polishing and buffing compounds, cyanide, pottery, textiles, explosives, cyanamide, phenol, barium products, basic magnesium carbonate, nitrates, alcohol, oxygen, dyes, for correcting the acidity of soils, for kalsomine, wire coating, purification of blast furnace gases, and for sanitation.

*Paper read at the fourteenth annual meeting of the American Institute of Chemical Engineers, Baltimore, Md., Dec. 9, 1921.

[1] *Lime Light*, pp. 106-113 (1904).

[2] E. F. Burchard and W. E. Emley, U. S. G. S., Mineral Resources, 1913, Part II, pp. 1509-1593.

[3] *Concrete Cement*, vol. 5, pp. 20-22 (July, 1914).

[4] *J. Ind. Eng. Chem.*, vol. 10, pp. 214-219 (March, 1918).

[5] Bureau of Standards Circular 30, Second Edition.

data published by the U. S. Geological Survey indicate that lime producers in 1918 sold about 1,900,000 tons for chemical uses, representing roughly 60 per cent of their total. In 1919 this percentage dropped to about 51 per cent, but rose in 1920 to more than 53 per cent. The war undoubtedly had its effect in making the 1918 figure somewhat abnormal, but the indications are that the chemical uses will continue to be the major outlet for our lime production.

The chemical uses of lime may be grouped under nine main heads, which are sanitation, purification of materials, food, catalytic processes, medicine, general utility, byproducts utilization, raw material in the manufacturing industries and miscellaneous.

Raw Material in the Manufacturing Industries

As a raw material in the manufacturing industries, lime functions in processes of saponification, dehydration, hydrolysis, causticization, distillation, high-pressure processes, absorption of gases, coagulation, precipitation, solution, high temperature processes and neutralization of acids.

In high temperature processes lime is used as a fluxing agent in the open-hearth process of steel purification and in the recovery of zinc in the roasting of zinc ore. It finds use as a fluxing agent also in the ceramic and porcelain industries. Lime in the form of very fine quicklime is used as a lubricating agent for dies in drawing steel wire. In electrothermic operations lime is used in the refining of steel, nickel and copper. There is evidence that lime may function as a solute in fused melts whereby alkaline earth metals are produced by electrolysis. Lime functions as an oxidizing agent for carbon under the conditions existing in the manufacture of calcium carbide, cyanamide and silicide and metallic magnesium in the fertilizer and metallurgical industries. Lime is used in fusions such as with silicates to form glass, with alkali hydroxides in making soda-lime and alkali peroxides, with chromite in making chromates, and with clay in the manufacture of aluminum and barium compounds. The manufacture of dead-burned dolomite is possible with the use of lime by a high-temperature calcination process. The manufacture of pottery, decolorizing carbon and silica brick can be accomplished by a baking process in which lime is used with clay, tarry material and kieselguhr, respectively.

In saponification processes, lime functions as a saponification agent for oils in making lubricating greases and various other tar products in the petroleum industry. Organic salts may be saponified with lime in making hyroxides in the dye and organic chemical industry. The action of lime as a saponifying agent for fats, waxes or greases is involved in the cleansing of textiles and also in the manufacture of soap, glue, glycerine, lubricating greases and paints in the animal products industry.

As a dehydrating agent, lime is used in the manufacture of industrial alcohol. It also finds a place in the petroleum industry for the dehydration of petroleum and greases.

Lime is used as a hydrolyzing agent in the manufacture of hydrolyzed glue for use in the prevulcanization treatment of rubber. It can also be used as such in the manufacture of ammonia from aluminum nitride and in the manufacture of pulp cloth from cellulose.

Causticization with lime is involved in the manufacture of alkali hydroxides from sulphates, carbonates and phosphates. Such processes are used extensively in the paper industry for making soda and sulphate pulp, in the inorganic chemical industry for making alkali salts, in the textile industry for mercerizing cloth and for the manufacture of hypochlorites for bleaching purposes, and in the animal products industry for making alkali soaps.

The use of lime as a coagulating agent is extensive in the purification of turbid water for use in making artificial ice and for general municipal purposes. It functions similarly in the settling of ore slimes for the recovery of precious metals in the mining industry, and in the defecation of sugar juices both by the carbonation and sulphitation processes in the cane and beet sugar industry. In the clarification of sorghum juice, for making molasses and in the flocculation of clay in making compounding ingredients for the rubber industry, lime functions as a coagulating agent.

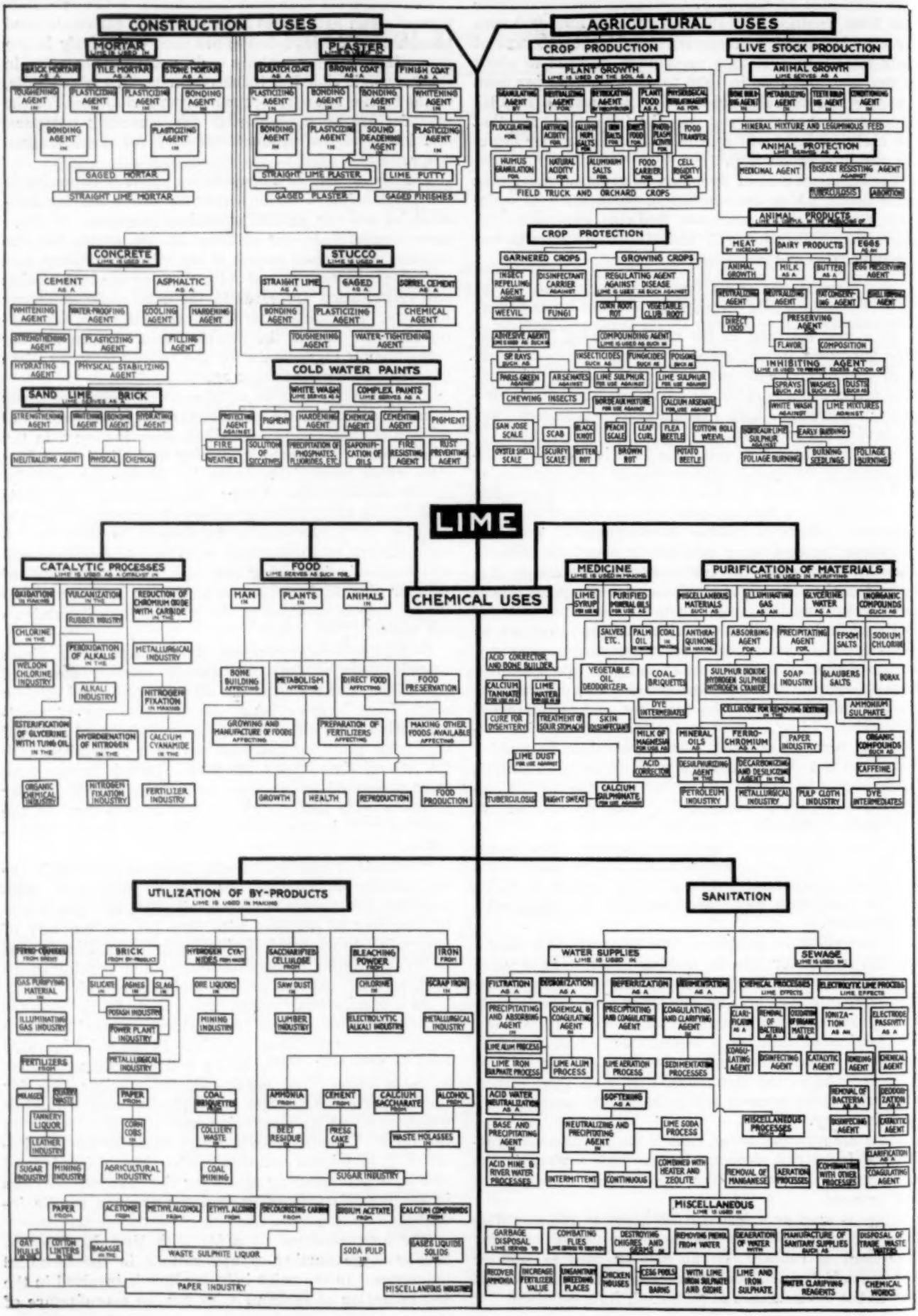
The action of lime as an absorption agent for gases is made use of in the manufacture of acetic acid and acetate of lime in the wood-distillation industry, in the manufacture of bleaching powder and alkali hypochlorites which involve the absorption of chlorine, and also in the manufacture of lime nitrogen salts and nitric acid by the absorption of oxides of nitrogen. The absorption of carbon dioxide by lime is involved in the manufacture of precipitated calcium carbonate, phenol and magnesia insulating material. The absorption of sulphur dioxide, hydrogen sulphide and hydrogen cyanide by lime is involved in the purification of illuminating gases.

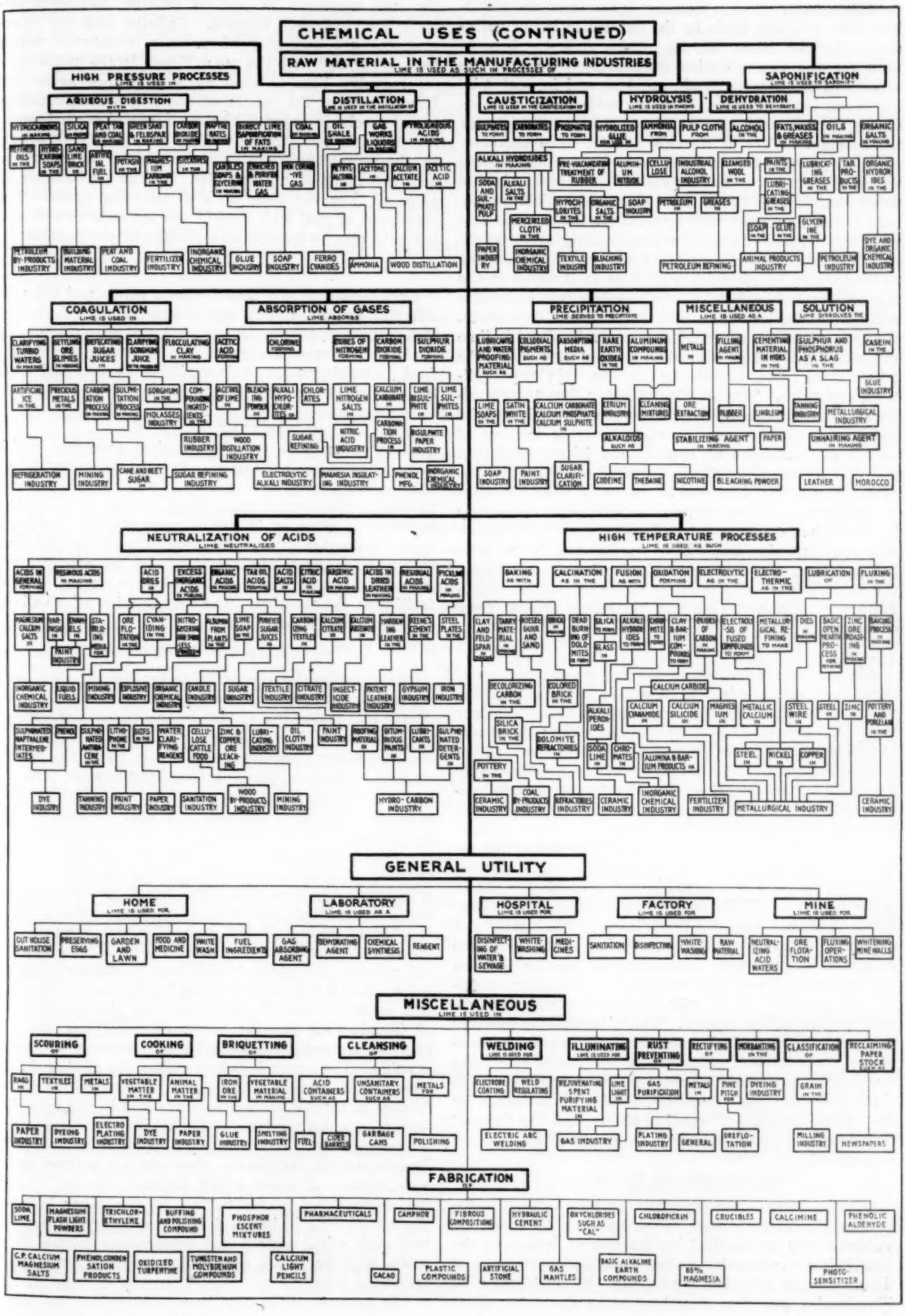
In high-pressure processes, lime is used in the direct saponification of fats, in making candles, soap and glycerine. The manufacture of refined oils and calcium soaps from hydrocarbons, the manufacture of sand-lime brick from silica and the manufacture of artificial fuel from peat, tar and coal can be accomplished with the use of lime under pressure. Potash is extracted from greensand and feldspar by aqueous digestion under pressure with lime. This process is also used in the glue industry in the making of siccatives from naphthanates.

Processes of distillation with lime are involved in the manufacture of enriched and purified water gas, ferrocyanides and ammonia. Coal, oil shale and gas works liquors may be distilled with lime for the recovery of ammonia. In the wood-distillation industry, lime is used in the distillation of pyroligneous acid in making methanol, acetone, calcium acetate and acetic acid.

As a precipitating agent, lime is used in the soap industry for making lime soaps which are used as lubricants and waterproofing material. In the paint industry lime is used for precipitating colloidal pigments such as satin white. The sugar industry employs lime for precipitating carbonates, phosphates and sulphites which function as absorption media for impurities in the juice. Cleaning mixtures are made by the precipitation of aluminum compounds with lime. Lime is used also as a precipitating agent for the rare earth oxides in the manufacture of cerium for the gas mantle industry.

The neutralization of acids with lime has an unusually large number of applications in the technical industries. In the paint industry lime is involved in the neutralization of resinous acids for the manufacture of


LIME
CONSTRUCTION USES
MORTAR
BRICK MORTAR AS A
TILE MORTAR AS A
STONE MORTAR AS A
TOUGHENING AGENT
PLASTICIZING AGENT
PLASTICIZING AGENT
BONDING AGENT
BONDING AGENT
PLASTICIZING AGENT
GAGED MORTAR
STRAIGHT LIME MORTAR
PLASTER
SCRATCH COAT AS A
BROWN COAT AS A
FINISH COAT AS A
PLASTICIZING AGENT
BONDING AGENT
BONDING AGENT
WHITENING AGENT
BONDING AGENT
PLASTICIZING AGENT
SOUND DEADENING AGENT
PLASTICIZING AGENT
STRAIGHT LIME PLASTER
LIME PUTTY
GAGED PLASTER
GAGED FINISHES
CONCRETE
CEMENT AS A
ASPHALTIC AS A
WHITENING AGENT
WATER-PROOFING AGENT
COOLING AGENT
HARDENING AGENT
STRENGTHENING AGENT
PLASTICIZING AGENT
FILLING AGENT
HYDRATING AGENT
PHYSICAL STABILIZING AGENT
SAND LIME BRICK
STRENGTHENING AGENT
WHITENING AGENT
BONDING AGENT
HYDRATING AGENT
NEUTRALIZING AGENT
PHYSICAL
CHEMICAL
STUCCO
STRAIGHT LIME AS A
GAGED AS A
PORTLAND CEMENT AS A
BONDING AGENT
PLASTICIZING AGENT
CHEMICAL AGENT
TOUGHENING AGENT
WATER-TIGHTENING AGENT
COLD WATER PAINTS
WHITE WASH
COMPLEX PAINTS
PROTECTING AGENT AGAINST
PIGMENT
HARDENING AGENT
CHEMICAL AGENT
CEMENTING AGENT
PIGMENT
FIRE
WEATHER
SOLUTION OF SILICATIONS
PRECIPITATION OF PHOSPHATES, FLUORIDES, ETC.
SAPONIFICATION OF OILS
FIRE RESISTING AGENT
RUST PREVENTING AGENT
AGRICULTURAL USES
CROP PRODUCTION
PLANT GROWTH
LIME IS USED ON THE SOIL AS A
GRANULATING AGENT BY
NEUTRALIZING AGENT FOR
INTRODUCING AGENT BY INOCULATION
PLANT FOOD AS A
PHYSIOLOGICAL REGULATOR AS FOR
FLOCCULATING FOR
ARTIFICIAL ACIDITY FOR
ALUMINUM IRON SALTS FOR
IRON SALTS FOR
DIRECT PLANT FOOD
PHOSPHORIC ACID ACTIVE FOR
FOOD TRANSFER
HUMUS GRANULATION FOR
NATURAL ACIDITY FOR
ALUMINUM SALTS FOR
FOOD CARRIER FOR
CELL RIGIDITY FOR
FIELD TRUCK AND ORCHARD CROPS
CROP PROTECTION
GARNERED CROPS
GROWING CROPS
INSECT REPELLING AGENT AGAINST
DISINFECTANT CARRIER AGAINST
REGULATING AGENT AGAINST DISEASE
LIME IS USED AS SUCH AGAINST
WEEVIL
FUNGI
CORN ROOT ROT
VEGETABLE CLUB ROOT
ADHESIVE AGENT LIME IS USED AS SUCH IN
COMPOUNDING AGENT LIME IS USED AS SUCH IN
SPRAYS SUCH AS
INSECTICIDES SUCH AS
FUNGICIDES SUCH AS
POISONS SUCH AS
PARIS GREEN AGAINST
ARSENATES AGAINST
LIME SULPHUR FOR USE AGAINST
LIME SULPHUR FOR USE AGAINST
CHEWING INSECTS
BORDEAUX MIXTURE FOR USE AGAINST
CALCIUM ARSENATE FOR USE AGAINST
SAN JOSE SCALE
SCAB
BLACK KNOT
PEACH SCALE
LEAF CURL
FLEA BEETLE
COTTON BOLL WEEVIL
OYSTER SHELL SCALE
SCURFY SCALE
BITTER ROT
BROWN ROT
POTATO BEETLE
LIVE STOCK PRODUCTION
ANIMAL GROWTH
LIME SERVES AS A
BONE BUILDING AGENT
METABOLIZING AGENT
TEETH BUILDING AGENT
CONDITIONING AGENT
MINERAL MIXTURE AND LEGUMINOUS FEED
ANIMAL PROTECTION
LIME SERVES AS A
MEDICINAL AGENT
DISEASE RESISTING AGENT AGAINST
TUBERCULOSIS
ABORTION
ANIMAL PRODUCTS
LIME IS USED IN THE PRODUCTION OF
MEAT BY INCREASING
DAIRY PRODUCTS
EGGS AS AN
ANIMAL GROWTH
MILK AS A
BUTTER AS A
EGG PRESERVING AGENT
NEUTRALIZING AGENT
NEUTRALIZING AGENT
FAT CURDLERIZING AGENT
SALT CURING AGENT
DIRECT FOOD
PRESERVING AGENT
FLAVOR
COMPOSITION
INHIBITING AGENT
LIME IS USED TO PREVENT EXCESS ACTION OF
SPRAYS SUCH AS
WASHES SUCH AS
DUSTS SUCH AS
WHITE WASH AGAINST
LIME MIXTURES AGAINST
BORDEAUX-LIME SULPHUR AGAINST
EARLY BUDDING
FOLIAGE BURNING
BURNING SEEDLINGS
FOLIAGE BURNING
CHEMICAL USES
CATALYTIC PROCESSES
LIME IS USED AS A CATALYST IN
OXIDATIONS IN MAKING
VULCANIZATION IN THE
REDUCTION OF CHROMIUM OXIDE WITH CARBIDE IN THE
RUBBER INDUSTRY
CHLORINE IN THE
PEROXIDATION OF ALKALIS IN THE
METALLURGICAL INDUSTRY
WELDON CHLORINE INDUSTRY
ALKALI INDUSTRY
NITROGEN FIXATION IN MAKING
ESTERIFICATION OF GLYCERINE WITH TUNG OIL IN THE
HYDROGENATION OF NITROGEN IN THE
CALCIUM CYANAMIDE IN THE
ORGANIC CHEMICAL INDUSTRY
NITROGEN FIXATION INDUSTRY
FERTILIZER INDUSTRY
FOOD
LIME SERVES AS SUCH FOR
MAN IN
PLANTS IN
ANIMALS IN
BONE BUILDING AFFECTING
METABOLISM AFFECTING
DIRECT FOOD AFFECTING
FOOD PRESERVATION
GROWING AND MANUFACTURE OF FOODS AFFECTING
PREPARATION OF FERTILIZERS AFFECTING
MAKING OTHER FOODS AVAILABLE AFFECTING
GROWTH
WEALTH
REPRODUCTION
FOOD PRODUCTION
MEDICINE
LIME IS USED IN MAKING
LIME SYRUP FOR USE AS
PURIFIED MINERAL OILS FOR USE AS
SALVES ETC.
PALM OIL IN MAKING
COAL IN MAKING
ANTHRAQUINONE IN MAKING
ACID CORRECTOR AND BONE BUILDER
VEGETABLE OIL DEODORIZER
COAL BRIQUETTES
CALCIUM TANNATE FOR USE AS
LIME WATER FOR USE AS
DYE INTERMEDIATES
CURE FOR DYSENTERY
TREATMENT OF SOUR STOMACH
SKIN DISINFECTANT
MILK OF MAGNESIA FOR USE AS
ACID CORRECTION
LIME DUST FOR USE AGAINST
TUBERCULOSIS
NIGHT SWEAT
CALCIUM SULPHONATE FOR USE AGAINST
PURIFICATION OF MATERIALS
LIME IS USED IN PURIFYING
MISCELLANEOUS MATERIALS SUCH AS
ILLUMINATING GAS AS AN
GLYCERINE WATER AS A
INORGANIC COMPOUNDS SUCH AS
ABSORBING AGENT FOR
PRECIPITATING AGENT FOR
EPSOM SALTS
SODIUM CHLORIDE
SULPHUR DIOXIDE HYDROGEN SULPHIDE HYDROGEN CYANIDE
SOAP INDUSTRY
GLAUBERS SALTS
BORAX
CELLULOSE FOR REMOVING SETTING IN THE
AMMONIUM SULPHATE
MINERAL OILS AS
FERRO-CHROMIUM AS A
PAPER INDUSTRY
ORGANIC COMPOUNDS SUCH AS
CAFFEINE
DESULPHURIZING AGENT IN THE
DECARBONIZING AND DESULPHURIZING AGENT IN THE
PETROLEUM INDUSTRY
METALLURGICAL INDUSTRY
PULP CLOTH INDUSTRY
DYE INTERMEDIATES
UTILIZATION OF BY-PRODUCTS
LIME IS USED IN MAKING
FERRO-CHROMIUM FROM SLAG
BRICK FROM BY-PRODUCT
HYDROGEN CYANIDES FROM GAS
SACCHARIFIED CELLULOSE FROM
BLEACHING POWDER FROM
IRON FROM
GAS PURIFYING MATERIAL
SILICATE IN
ASHES IN
SLAG IN
ORE LIQUORS IN
SAW DUST IN
CHLORINE IN
SCRAP IRON IN
ILLUMINATING GAS INDUSTRY
POTASH INDUSTRY
POWER PLANT INDUSTRY
METALLURGICAL INDUSTRY
MINING INDUSTRY
LUMBER INDUSTRY
ELECTROLYTIC ALKALI INDUSTRY
METALLURGICAL INDUSTRY
FERTILIZERS FROM
MOLASSES
SUGAR WASTE
PAPER FROM
CORN COBS IN
COAL BRIQUETTES FROM
COLLIERY WASTE IN
TANNERY LIQUOR
LEATHER INDUSTRY
SUGAR INDUSTRY
MINING INDUSTRY
AGRICULTURAL INDUSTRY
COAL MINING
AMMONIA FROM
CEMENT FROM
CALCIUM SACCHARATE FROM
ALCOHOL FROM
BEET RESIDUE
PRESS CAKE IN
WASTE MOLASSES IN
SUGAR INDUSTRY
PAPER FROM
ACETONE FROM
METHYL ALCOHOL FROM
ETHYL ALCOHOL FROM
DECOLORIZING CARBON FROM
SODIUM ACETATE FROM
CALCIUM COMPOUNDS FROM
OAT HULLS IN PAPER
COTTON LINTERS IN PAPER
BAGASSE IN THE
WASTE SULPHITE LIQUOR
SODA PULP IN
CASEIN LIQUORS SOLIDS IN
PAPER INDUSTRY
MISCELLANEOUS INDUSTRIES
SANITATION
WATER SUPPLIES
LIME IS USED IN
SEWAGE
LIME IS USED IN
FILTRATION AS A
DEMINERALIZATION AS A
SUPERIZATION AS A
SEDIMENTATION AS A
CHEMICAL PROCESSES LIME EFFECTS
ELECTROLYTIC LIME PROCESS LIME EFFECTS
PRECIPITATING AND ABSORBING AGENT IN
CHEMICAL & COAGULATING AGENT IN
PRECIPITATING AND COAGULATING AGENT
COAGULATING AND CLARIFYING AGENT IN
CLARIFICATION AS A
REMOVAL OF BACTERIA AS A
OXIDATION OF ORGANIC MATTER AS A
IONIZATION AS AN
ELECTRODE PASSIVITY AS A
LIME ALUM PROCESS
LIME IRON SULPHATE PROCESS
LIME ALUM PROCESS
LIME AERATION PROCESS
SEDIMENTATION PROCESSES
COAGULATING AGENT
DISINFECTING AGENT
CATALYTIC AGENT
OXIDIZING AGENT
CHEMICAL AGENT
ACID WATER NEUTRALIZATION AS A
SOFTENING AS A
REMOVAL OF BACTERIA AS A
DEODORIZATION AS A
BASE AND PRECIPITATING AGENT IN
NEUTRALIZING AND PRECIPITATING AGENT IN
LIME SODA PROCESS
MISCELLANEOUS PROCESSES USE AS
DISINFECTING AGENT
CATALYTIC AGENT
ACID MINE & RIVER WATER PROCESSES
INTERMITTENT
CONTINUOUS
COMBINED WITH HEATER AND ZEOLITE
CLARIFICATION AS A
REMOVAL OF MANGANESE
AERATION PROCESSES
COMBINATION WITH OTHER PROCESSES
COAGULATING AGENT
MISCELLANEOUS
LIME IS USED IN
GARBAGE DISPOSAL LIME SERVES TO
COMBATING FLIES LIME SERVES TO CONTROL
DESTROYING CHIGRES AND GERMS IN
REMOVING PHENOLS FROM WATER
DEAERATION OF WATER WITH
MANUFACTURE OF SANITARY SUPPLIES SUCH AS
DISPOSAL OF TRADE WASTE TREATED
RECOVER AMMONIA
INCREASE FERTILIZER VALUE
MOSQUITO BREEDING PLACES
CHICKEN HOUSES
EGG PODS IN BARNS
WITH LIME IRON SULPHATE AND GLUE
LIME AND IRON SULPHATE
WATER CLARIFYING REAGENTS
CHEMICAL WORKS


CHEMICAL USES (CONTINUED)
RAW MATERIAL IN THE MANUFACTURING INDUSTRIES
LIME IS USED AS SUCH IN PROCESSES OF
HIGH PRESSURE PROCESSES
LIME IS USED IN
AQUEOUS DIGESTION
DISTILLATION
CAUSTICIZATION
HYDROLYSIS
DEHYDRATION
SAPONIFICATION
COAGULATION
ABSORPTION OF GASES
PRECIPITATION
MISCELLANEOUS
SOLUTION
NEUTRALIZATION OF ACIDS
HIGH TEMPERATURE PROCESSES
GENERAL UTILITY
HOME
LABORATORY
HOSPITAL
FACTORY
MINE
MISCELLANEOUS
SCOURING
COOKING
BRIQUETTING
CLEANSING
WELDING
ILLUMINATING
RUST PREVENTING
RECTIFYING
MORDANTING
GLASSIFICATION
RECLAIMING PAPER STOCK
FABRICATION

varnishes and enamels. Certain liquid fuels are stabilized with products made by the neutralization of resinous acids with lime. In the mining industry lime is used for the neutralization of acid ores both in the process of ore flotation and cyaniding and in neutralizing excess leaching acids. Pickling acids in the steel industry are neutralized with lime, as is also residual acid in the manufacture of Keene's cement. The manufacture of patent leather involves a hardening process which may require the neutralization of acids in the dried leather with lime. The insecticide calcium arsenate is made commercially by neutralizing arsenic acid with lime. Lime is used as a neutralizing agent in the manufacture of calcium citrate and citric acid. The neutralization of tar acids with lime is involved in the manufacture of certain kinds of roofing material, bituminous paints, lubricants and sulphonated detergents. Organic acids are commercially neutralized with lime in purifying sugar juices and in making lime soaps, the latter being used in making candles, lubricants, oilcloth and paint. The practice of using lime to neutralize excess acids enters into a large number of industrial processes, of which may be mentioned the making of phenol and sulphonated naphthalene intermediates in the dye industry, synthetic tanning materials in the tanning industry, lithopone in the paint industry, sizes in the paper industry, water-clarifying agents for use in sanitation, cellulose cattle food in the wood byproducts industry, zinc and copper ore leaching in the mining industry, the extraction of nicotine from tobacco, the manufacture of albumen from plants and the manufacture of nitroglycerine and smokeless powder from cellulose.

Sanitation

The uses of lime in sanitation may be grouped under three main heads—viz., the treatment of water supplies, the treatment of sewage and miscellaneous sanitary uses. Treatment of sewage may be either the direct chemical process or the electrolytic-lime process. In the direct chemical process the action of the lime is chiefly that of clarification, the removal of bacteria and possibly the oxidation of organic matter. In the electrolytic-lime process lime effects ionization, electrode passivity, deodorization, clarification and indirectly the removal of bacteria. In the treatment of water supplies lime is used as a precipitating and absorbing agent in deferrization processes and processes of ordinary filtration. It is used also as a precipitating, coagulating and neutralizing agent in water-softening processes. The treatment of the water supplies with lime also includes the neutralization of acid waters and such other miscellaneous processes as the aëration process and the ordinary sedimentation process. The miscellaneous sanitary uses of lime include its use in the disposal of trade waste waters, the manufacture of water-clarifying agents, the destroying of chigres and germs such as in chicken houses, the combating of the fly nuisance by destroying unsanitary breeding places, and the disposal of garbage by processes which provide for the recovery of ammonia.

Purification of Materials

Certain inorganic compounds such as epsom salts, sodium chloride, glaubers salts, borax and ammonium sulphate may be purified by the use of lime. In the soap industry, glycerine water is purified by the use of lime as a precipitating agent. In the purification of illuminating gas, lime functions as an absorbing agent for such materials as sulphur dioxide, hydrogen sulphide and hydrogen cyanide. Caffeine and dye intermediates are examples of organic compounds which may be purified with the use of lime. In the metallurgical industry lime is used as a purifying agent for ferrochromium, the lime functioning as a decarbonating and desilicizing agent. The basic open-hearth process for steel involves the use of lime as a purifying agent. In the petroleum industry lime may be used for the desulphurizing of mineral oils. In the purification of palm oil lime functions as a deodorizing agent. The treatment of coal with lime in the manufacture of coal briquets may be considered a process of purification.

Food

Lime functions as a food for man, plants and animals, affecting growth, health, reproduction and food production. It functions in the growing and manufacture of food, in the manufacture of fertilizers, in preserving food, in making other foods available, in bone and teeth building and in metabolism in general.

Catalytic Processes

Lime enters into certain chemical processes which may be considered catalytic. In the vulcanization of rubber lime serves as a carrier of sulphur. Lime may be used in the contact mass which is used in the hydrogenation of nitrogen in the nitrogen fixation industry. In the reduction of chromium oxide with carbide lime catalytically affects the reaction. In the manufacture of calcium cyanamide from carbide an excess of lime facilitates the reaction. The peroxidation of alkalis is catalyzed with lime.

Utilization of Byproducts

The metallurgical industry makes use of lime as a fluxing agent in the recovery of scrap iron. This industry also makes use of lime in the disposal of byproduct slag in making building brick. In the electrolytic alkali industry byproduct chlorine is recovered by absorption with lime, forming bleaching powder. In the lumber industry byproduct sawdust is saccharified with acids in making cattle feed and lime is used in the neutralization of the excess acid. In the mining industry waste ore liquors may be treated with lime for the recovery of hydrogen cyanide. Potash feldspar quarry waste may be used with lime in the manufacture of fertilizers. In the coal-mining industry, colliery waste is admixed with lime and made into coal briquets. In the manufacture of potash from greensand the byproduct silicates are utilized with lime in making building brick. Brick may also be made by the use of lime and coal ashes or blast-furnace slag. In the manufacture of illuminating gas the waste gas-purifying material may be treated with lime in the recovery of ferrocyanide. The sugar industry makes use of lime in the recovery of ammonia from beet residue, in the manufacture of cement from press cake and in the manufacture of calcium saccharate, alcohol and fertilizers from waste molasses. Waste tannery liquor is utilized with lime in making fertilizers. Corncobs are utilized in the manufacture of paper which involves the use of lime for neutralizing excess acids. In the paper industry the use of lime is involved in the recovery of acetone, methanol, ethyl alcohol and decolorizing carbon from waste sulphite liquor and sodium acetate from waste soda pulp liquor.

The general utility of lime extends to the home,

laboratory, hospital, factory and mine. In the mine, lime is used for the neutralization of acid mine waters, for the neutralization of ores in flotation processes, in fluxing operations and for the whitening of mine walls. In the factory, lime is used as a raw manufacturing material, as a cold water paint and for disinfecting and general sanitary purposes. In the laboratory, lime finds use in a large number of ways, including its use as a chemical reagent, as a dehydrating agent and as a gas-absorbing agent. Around the home, lime is used in whitewash and cold-water paints, it is used on the field, garden and lawn, for preserving eggs, for outhouse sanitation, as a fuel ingredient and as a food and medicine. In the hospital, lime finds use for general sanitary purposes.

Miscellaneous

Lime acts as a scouring agent in several industries, including the scouring of rags in the paper industry, the scouring of textiles in the dyeing industry and of metals in electroplating processes. Lime is used in the cooking of certain materials such as animal matter in the manufacture of glue and of vegetable matter in the manufacture of paper and dyes. The briquetting of iron ore in the smelting industry involves the use of lime, as does also the briquetting of such vegetable matter as lignite in making fuel. Lime is used as a cleansing agent for wooden containers such as cider and oil barrels, for metals of various kinds as a preliminary to the polishing process and it serves as a cleanser for unsanitary containers such as garbage cans. In electric welding, lime serves as a weld regulator and coating for the electrodes. In illumination, lime is used directly in the limelight and as a gas-purifying material in the gas industry. Lime serves to retard rusting of metals such as iron under certain conditions. In ore flotation pine oil may be rectified with lime. Lime is sometimes used in the dye industry for mordanting, particularly in logwood and turkey red dyeing. The milling industry makes use of lime to remove smut spores and thereby improve the grade of the grain.

The miscellaneous uses of lime include the fabrication of a large number of products, some of the more important of which are phenolic aldehyde, photosensitizers, calcimine, crucibles, 85 per cent magnesia, chlorpicrin, basic alkaline earth compounds, alkaline earth oxychlorides, gas mantles, hydraulic cement, artificial stone, fibrous composition, camphor, cacao, pharmaceuticals, calcium light pencils, phosphorescent mixtures, tungsten and molybdenum compounds, buffing and polishing compounds, oxidized turpentine, trichlorethylene, magnesium flashlight powder, soda-lime, calcium and magnesium salts, antiseptics, quick drying varnishes, and carbonizers for metals.

Construction Uses

The lime industry had its birth in its construction uses. The most ancient record of the use of lime is as a mortar and plaster. The development of the art of lime manufacture and of its use in construction was well on its way before our technical manufacturing industries began to develop. As a result of this time element we find the art of the construction uses of lime in a relatively advanced state compared with the other uses. Although the construction uses of lime are not numerous, yet the tonnage is very important. In 1918, about 28½ per cent of the lime manufacturers' tonnage was for construction uses. In recent years this percentage has increased somewhat. With the improvements in the quality of material, the standardization of the product and the development of new construction materials, this use of lime bids fair to thrive, especially in the next few years.

Mortar

The use of lime in mortar is the most impotrant one in the construction field. It is used in brick mortar, tile mortar and stone mortar, both in the form of gaged and straight lime mortar. In these materials, lime performs functions which have been explained in various ways. Lime serves as a bonding agent by taking on a stone-like set through the process of recarbonation and thereby, with the intermixed sand, not only binds the main elements of the structure but also fills the larger voids. Limes of various kinds perform varying degress of plasticizing action in the wet mortar, affecting the ease with which it is spread. Characteristic also of lime mortar is a certain resiliency or elasticity which has been expressed by attributing to lime the function of a toughening agent.

Plaster

Lime is used in the scratch coat, brown coat and finish coat of plaster. These may either be straight lime or gaged plaster in which lime serves as a bonding agent, whitening agent, plasticizing agent and as a sound-deadening agent.

Concrete

Lime is used in both cement and asphaltic concrete. In asphaltic concrete lime serves as a hardening agent, filling agent and cooling agent. In cement concrete, lime serves as a hydrating agent, plasticizing agent, strengthening agent, water-tightening agent and whitening agent, and as a physical stabilizing agent to prevent segregation.

Stucco

There are three kinds of stucco—viz., straight lime and gaged stucco and sorrel cement. In the first two, lime serves as a bonding agent, plasticizing agent, toughening agent and water-tightening agent. In sorrel cement the action of lime is primarily chemical instead of physical.

Sand-Lime Brick

The function of lime in the manufacture of sand-lime brick is much the same as that of the other construction uses—viz., bonding (both physical and chemical), strengthening, whitening, hydration and neutralization.

Cold-Water Paints

Cold-water paints are conveniently divided into whitewash and complex paints. In these products lime serves as a protecting agent against wind and weather, as a pigment, as a hardening agent, as a cementing agent and as a rust-preventing agent. In certain of the complex paints it enters into chemical reactions such as the saponification of oils, the precipitation of phosphates, fluorides, etc., and in the solution of siccatives.

Agricultural Uses

The agricultural uses of lime may be divided into two main divisions—viz., crop production and livestock production. In crop production, lime is made use of both in connection with plant growth and with crop protection. In livestock production lime is made use

of in connection with animal growth, animal protection and animal products.

Crop Production

Plant growth is affected by lime through its use on the soil. This use extends to field, truck and orchard crops, in connection with which it performs a number of functions. It corrects active free acid and thereby a chain of effects results, including the promotion of organic decay, nitrogen fixation and nitrification by organisms. It serves as a granulating agent by flocculation of colloids, both inorganic and organic, thereby improving the soil tilth with the long chain of physical benefits that result from such a change. It serves as a detoxicating agent by its action in precipitating aluminum and iron salts. Inside of the plant it serves as a direct plant food and as a physical regulating agent by its effect on food transfer, cell rigidity and protoplasm activity.

Crop protection with the use of lime extends to both the growing crop and the garnered crop. The use of lime in the protection of garnered crops involves its action as a disinfectant carrier against fungi and as an insect-repelling agent against weevil.

The protection of growing crops by lime enters into a number of ramifications in which it performs four important and distinct functions. Lime serves as an adhesive agent in sprays, such as paris green and the arsenates for use against chewing insects. Lime is used directly as a regulating agent against such diseases as corn root rot and vegetable clubfoot. Lime performs the function of an inhibiting agent against excess action of such sprays, washes and dusts, as whitewash, lime mixtures and bordeaux lime-sulphur, which are used in preventing foliage burning, seedling burning and early budding.

The most important use of lime, however, in crop protection is as a compounding ingredient for insecticides, fungicides and poisons such as lime sulphur, bordeaux mixture and calcium arsenate respectively. These materials are used in combating the San José scale, oystershell scale, scurfy scale, scab, black-knot, bitterroot, peach scale, brown rot, leaf curl, flea-beetle, potato-beetle and cotton-boll weevil.

Livestock Production

Animal growth is affected by lime through its use in feed both leguminous food and mineral mixtures wherein lime functions as an agency for bone building, conditioning, metabolism and teeth building. It affects animal protection both as a medical agent and as a disease-resisting agent against tuberculosis and abortion. The animal products that are affected by the use of lime are dairy products and eggs. Lime is a shell-forming agent and thereby affects the production of eggs. In the form of lime water it is a preservative for eggs. The manufacture of butter employs the use of lime as a milk food, and as a neutralizing agent for sour cream. It is also thought to function as a preserving agent for flavor and composition.

Closure

This review of the functions that lime performs in its numerous uses indicates that it is a most remarkable chemical. It is doubtful if there is any other chemical that is used in such a large number of diverse processes. In the construction uses of lime it performs at least seventeen different functions. In its agricultural uses it performs at least nineteen different functions. In its chemical uses it functions in a very much larger number of ways. Not only is lime as a chemical characterized by the large number of functions it performs but, what is more important, by the exceedingly diverse nature of its functional capacity. It is used as an oxidizing agent and as a reduction agent, it is used as a dissolving agent and a precipitating agent, it is used for the absorption of gases and for the expulsion of gases, in one form it acts as a dehydrating agent and in another form as a hydrolizing agent. Surely it is one of the most versatile of chemicals.

The nation is fortunately provided with an adequate supply of the raw materials for lime manufacture and with a lime industry adequately prepared to supply all demands with a high-grade standardized product. The industry can also produce various kinds of limes of widely varying chemical and physical properties. Lime is distinguished therefore not only by its versatility but by its cheapness, general availability and by its adaptability to the special requirements of its various uses.

What the industry needs is a larger tonnage outlet in the way of new and larger uses. It is the chemical engineer who can supply that tonnage. Fundamental research is needed on lime, its properties and uses under such headings as lime as a coagulating agent, lime as a dehydrating agent, etc. The field is a fertile one. The great potentiality of lime as a national asset has not been adequately realized.

Extent of Potash Deposits in Oil Fields

The discovery of potash in samples of salts recently received by the United States Geological Survey from new wells bored for oil at two additional localities in western Texas extends the area in which small amounts of potash salts are known to occur about 30 miles north and 50 miles east of the area of previous discoveries.

Starting from the Means well, which is close to the New Mexico-Texas line, in Loving County, about 20 miles west of the southeast corner of New Mexico, the boundary of the area in which potash in notable richness has been found in the red beds runs southward for 30 miles to well No. 1, or the river well of the Pitts Oil Co., about 8 miles east of Barstow, thence east by northeast 130 miles to the McDowell well in northern Glasscock County, and thence north by northwest 50 miles to the Burns well, in Dawson County, from which it returns in a west by southwest direction to the starting point. Indications have also been found in the Panhandle.

As all these wells were drilled for oil and the easily soluble salts were of secondary consequence to the drillers, the samples recently forwarded, like the samples previously received from this region and analyzed, were accompanied by scant data relative to the water in the wells, the length of time it had been in contact with the salts, the condition of casing, etc. So many unknown conditions must therefore be taken into consideration that it is impossible to say whether the potash-rich salts already analyzed represent beds several feet or only a few inches thick. Core-drilling will have to be done in order to answer these questions. However, those who are drilling for oil in this region are showing more interest in the possibility that potash may be found in their wells and are preserving better samples and furnishing fuller data.

Results Achieved by the Corrosion Committee British Institute of Metals

Failure of Brass Condenser Tubes in Marine Service Is Caused by Lodgment of Solids, Harmless in Themselves, but Which Trap Corrosive Substances Formed During the Inevitable Process of Slow General Thinning

BY ERNEST E. THUM

IT IS rather difficult if not presumptuous to attempt to summarize the labors of the Corrosion Committee in a small space, since its investigations have been continuously under way for 10 years and its published reports cover 650 pages of the Institute's journal. The task is within reason only because but brief mention need be made of the early experiments, since they were much like groping in the dark. Current beliefs had first to be tested and discarded. Then a tremendous number of the ordinary "loss of weight" determinations were made before it became absolutely certain that this method was leading nowhere. Furthermore, some of the ideas strongly supported in the earlier reports have been greatly modified or even discredited by more precise work undertaken in later years.

Finally a carefully planned series of investigations disclosing the fundamental mechanism of the corrosion of brass was performed, and the information thus disclosed was used in interpreting the performance of new tubes in condensers operating under known circumstances.

In passing, it would be well to remark that the published results have been confined to that particular problem—that is, the corrosion of condenser tubes[1] in water. The searcher for information on corrosion should therefore consider the limitations of these publications, and translate their results to other situations with great circumspection.

In view of these circumstances, attention can be kept almost wholly upon the more recent reports. These confine themselves to the action of 70:30 brass condenser tubes in sea water and fresh water.

ORGANIZATION OF RESEARCH ACTIVITIES

But first a word may be said about the organization. The founders of the Institute of Metals believed that its prime function would be to combine scientists, manufacturers and users in a joint quest for the reason why mysterious difficulties in the manufacture and use of alloys suddenly crop up, give no end of trouble and then as suddenly and mysteriously vanish. In view of the fact that many condenser tubes were apparently failing through corrosion after very short life, a committee was appointed and first met in May, 1910, under the chairmanship of Sir Gerard Muntz, to formulate ways and means to investigate that situation.

Mr. Bengough, then lecturer in metallurgy in the University of Liverpool, undertook to prepare a summary of the literature dealing with the corrosion of nonferrous alloys. He found that very few factors of the problem had been satisfactorily explained, and the first of his five reports—presented in September, 1911—was therefore confined to an exposition of the electrolytic theory of corrosion and a consideration of the possible causes of potential difference on the surface of an apparently uniform piece of metal.

Meanwhile the committee appealed for funds. Annual donations were made by the Institute, the Brass and Copper Tube Association, Lloyd's Register and various manufacturers, but with few exceptions the users of tubes refused to contribute on the ground that it was none of their affair, but that of the tube maker and the condenser manufacturer! An experimental plant, imitating carefully the details of a surface condenser on shipboard, was constructed at Liverpool University at a cost of about $1,000, but this was closed down after 9 months' running for the lack of operating funds. A figure between $3,000 and $4,000 financed the research up to 1917. Its investigations were then moved to London, enlarged under governmental auspices, and several problems connected with war work were submitted. The government donated £1,000 per year, and various manufacturers' associations more than duplicated that figure. With ampler funds, and the co-operation of many governmental and educational agencies, work has progressed along many lines, only a few of which can be mentioned here—indeed some of them are only indicated in the various reports.

CIRCUMSTANCES SURROUNDING TROUBLESOME CONDENSERS

One of the first requests made by the Corrosion Committee was for submission of defective tubes for examination, together with data on the service conditions. As a result many tubes were collected, but it was impossible to get more than a general idea of the problem in this manner, since the users could not define the surrounding circumstances with much clearness. To diagnose troubles, the consultant should know about the supply of cooling water—its chemical and mechanical analysis at seasonal variations and whether or not it is recirculated. He must know the metal comprising water mains, tubes and water ends; details of any attempted scheme of protection; the joint construction; whether tubes are often choked with sediment; the speed of cooling water and its temperature at outlet. Much information about the location of the trouble is needed: how soon did it occur; is it confined to a certain condition, to a few tubes in a certain part of one condenser, or to a localized part of a few tubes; is the steam properly deflected to all parts of the condenser; are the accessory parts also corroding? About the only way in which an investigator can be sure of getting this in-

[1] The following metals were used: Copper, zinc, aluminum, 70:30 brass, 61:39 brass (Muntz metal), 78:28:2 Pb special brass (Muntz "Nergandin"), 70:29:1 Sn Admiralty brass, 96:4 phosphor bronze and 92:8 copper-aluminum.

formation is to go to the plant himself, and this practice has lately been followed by the Corrosion Committee. In some cases fresh tubes have been placed and are under periodic inspection. At one power station an experimental condenser is in constant operation, and the Royal Navy has fitted half of a twin condenser with specially prepared tubes, under the committee's directions. From these commercial tests much reliable information will be forthcoming.

Study of Defective Tubes

Nearly all the brass tubes first submitted for examination had rapidly failed in service by corrosion at a few spots and in a manner which left behind more or less metallic copper, free of zinc. Depending upon past performance, a normal life to 50 per cent thinning was variously thought of as from 4 to 25 years, but it was common report that one shipment may show wide variations in durability (1 to 3). One 70:30 tube, taken from a trawler after 20 years' service, showed no trace of this apparent dezincification, and had lost not more than 0.05 mm. thickness. Such observations confirmed the general impression that localized attack was the culprit. Consequently it was essential to discover and remove the causes of pitting. The complexity of these causes may be inferred from the fact that if these same defective tubes were split, ground, polished and suspended in still sea water, they showed no localized dezincification. In 9 months the thickness had been uniformly reduced about 0.04 mm. and the pieces were covered by a film of dark brown copper oxide.

Despite the fact that concentrated attack was so early judged to be the damaging cause rather than general thinning (which indeed is always to be expected), it was not recognized until after the third report (1917) that repeated weighings of metallic samples would not answer the problem. Even when studying general thinning by non-selective attack, the actual amount of corrosion should be measured by the amount of metal disintegrated, which includes the metal passing into solution and remaining there, being redeposited as such, or being precipitated as an insoluble salt, the metal remaining on the sample in the form of oxide, and the metal lost by exfoliation. At present the total metal disintegrated is impossible to determine. A loss-of-weight experiment merely estimates the underlying metal plus the overlying scale. Successive weighings give no measure of the maximum penetration, the result becomes more inaccurate with time, and is subject to a great many uncertain factors. For instance, a table in the third report gives twelve duplicate experiments under conditions where only slow general corrosion at the rate of 0.05 mg. per sq.cm. per day was observed, but the average difference between pairs (supposedly identical) amounted to 19 per cent of the loss in weight. Determination of the minute amount of metal in the solutions and loose precipitate is difficult, and when used in calculations indicates only the weight of oxygen or other non-metallic products in the adherent scale. And finally the scale cannot be reduced or removed without affecting and destroying some of the underlying metal.

Those who still rely upon this kind of data may find a mine of information in the thousands of experiments on various kinds of condenser tubes published in the second and third reports.

Depth of pit is actually the most important consideration. Lacking some method of determining this, careful microscopic examination of the surface is the best method now known of attacking the problem of localized corrosion of 70:30 brass.

Protective Layers

Comparison of the 20-year old tube from the trawler with others which failed in less than that many months showed a very pronounced difference in the adhering scale. Early experiments also showed that the nature of the film first to form on the bright sample after immersion in sea water of various temperatures, aëration and dilution had a determining influence on the subsequent history of the experiment. In some cases this film will become darker with time, finally reaching a thickness of about 0.04 mm.; it is "glazed" in appearance and very tenacious. It does not seem to be wholly impervious to the corroding solution, since the metal in solution plus that in a loose precipitate gradually increases in amount. Yet it remains continuous and intact, and experiments extending nearly a year show the expected life of a tube with such a covering would be 15 to 20 years before 50 per cent thinning.

On the other hand, samples of metal of almost exactly the same composition, having no determinable differences in physical constitution or surface condition, when immersed in a companion beaker will first develop a film which cannot be distinguished from the other, but after a short lapse of time specks of adherent colored salt form here and there, grow and apparently perforate the original glaze. If removed, a red coppery area is seen. Localized corrosion has begun, and the tube is on the rapid road to failure. No reason can yet be given for these experimental results. Strangely enough, further work has shown that if a certain tube develops the resistant coating, all the tubes of that batch will also do so. Another batch, indistinguishable from the other, from the same reliable maker, will all develop the corrosive salt deposits!

Furthermore, when making brass cathodic to iron by an impressed current, under conditions similar to those obtaining in the electrolytic system of protection, the alloy remains bright after immersion in sea water, and at the end of, say, 3 weeks is found to have been covered with a thin, pinkish, translucent layer of calcium carbonate, quite hard, uniform and adherent. This layer does not entirely prevent corrosion, neither does the continual cathodic condition of the metal, for a thin layer of copper oxide gradually forms between the carbonate film and the metal, and general corrosion ensues—but at a very slow rate.

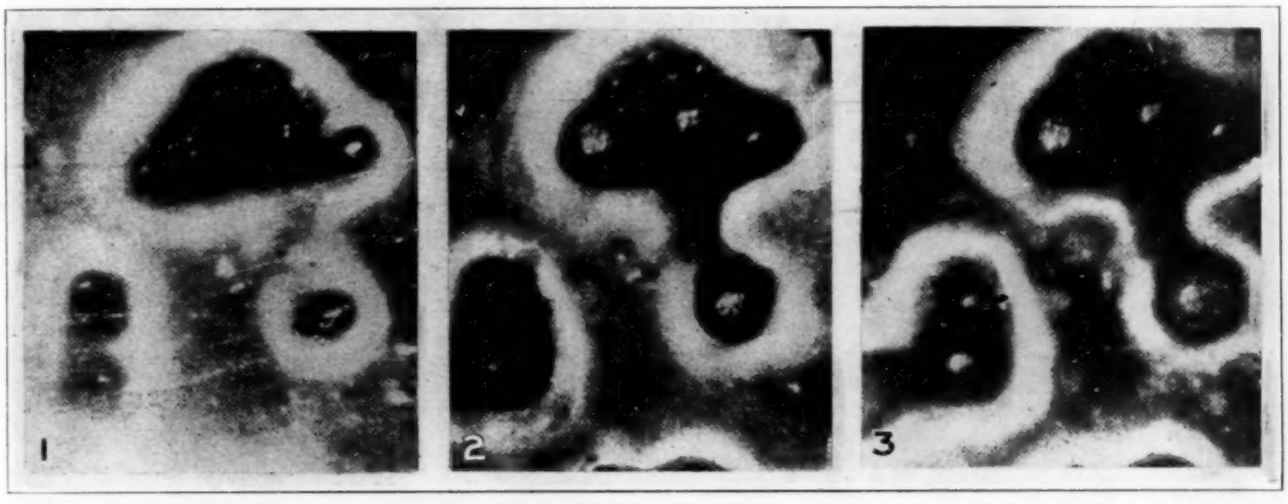
The Surface of a Tube

Such findings impressed Mr. Bengough and his associates with the fact that the surface layer—possessed by the original metal or built up upon it after immersion—had a determining influence on corrosion resistance to which nearly all other circumstances were secondary. Consequently great efforts have been made to determine the nature of these films.

A supporter of Beilby's amorphous theory would have no hesitation in accepting a statement that the surface of a tube, as received from the maker, is materially different from the underlying metal. For one thing, it is badly distorted from the cold work of the last draw. Previous annealings have doubtless volatilized some of the zinc and oxidized some of the copper. The actual surface should then comprise a thin sheath containing an unusual amount of amorphous metal, low in zinc and laminated with copper oxide.

A layer varying in thickness from 0.005 to 0.02 mm. can actually be removed from a section of 70:30 condenser tube. It flakes off, beginning at the edges, after a couple of weeks in 1 per cent NH_4Cl solution, and may often be recovered in sizable, coherent scales. Under the microscope it appears structureless; the outside surface still retains the draw lines, showing that the layer itself has resisted corrosion almost completely. The inside surface is more or less "pebbly." Analysis shows it to contain 73 per cent copper.

The underlying metal has been deeply attacked and its crystalline structure developed, thus exhibiting its essential difference from the resisting surface layer. Strangely enough, the reagent seems to attack the metal most readily along intercrystalline and intertwining plane material. It may be that the metal of the surface layer is different in some way from that which cements crystals and crystalline fragments. Or it may be that rapid corrosion on internal surfaces may be similar to that caused by mercurous nitrate in strained brass which eventually would fail by season cracking. These questions, and the differences between the surfaces which build up protective layers and those which do not, are problems yet to be solved.



FIGS. 1 TO 3—CAST ZINC SUSPENDED HORIZONTALLY IN DISTILLED WATER. OBLIQUE ILLUMINATION. × 70
Fig. 1—15 min. after immersion. Fig. 2—85 min. after immersion. Fig. 3—4 hours after immersion.

Corrosion of Zinc in Distilled Water

Zinc and copper were both closely observed, during the early stages of corrosion, hoping thereby to throw light upon the main problem—the rapid localized corrosion of 70:30 brass. A piece of smooth, clean, cast zinc (99.97 per cent pure) was immersed horizontally in distilled water[2] and observed under oblique illumination at 75 diameters. Figs. 1 to 6 from the fourth report are selected from a series given as typical.

Immediately upon immersion the surface showed numbers of small bright spots (minute holes) and scratches from the 00 emery paper used for final polish. Within 5 minutes curves ridges of bluish white material began to appear, which in 15 minutes had joined to form halos about portions of bare metal, bright and clear. (Fig. 1.) Outside the halos the metal gradually became covered with this gelatinous whitish material, shortly it became thick enough to obscure the scratches—however, there is little action in these regions, for when the precipitate is removed it is found that the scratches are not obliterated. It is an oxide or hydroxide of zinc, free of CO_2, and when dry exposes a somewhat nodular structure.

However, vigorous action proceeds inside the halos. Within 30 minutes definite pits seem to be forming as bright spots at the center of curvature of these ridges of zinc hydroxide. A definite convection is observed, upward and outward from the pits, building up the walls of the halo, toppling them over at times, whereupon the underlying corrosion will later be found to have advanced correspondingly. (Compare Figs. 2 and 6.) After 2 hours a secondary and inner halo forms around prominent pits. (Fig. 3.) This halo turns out to be an area of roughened surface, slowly and gradually spreading; it often is separated from the pit by a ring of unattacked metal; roughened surfaces sometimes occur in successive rings. (Fig. 4.) Despite appearances the pits are filled by a transparent gelatinous hydrated oxide. This is a fact of considerable importance, since it is often assumed that no corrosion exists in the absence of *visible* rust.

In about 4 hours feathery white crystals containing CO_3 appear at the outer surface and edges of the halos. Gradually all these details become obscured by the ever-increasing mass of corrosion products (Fig. 5), but a clear—sometimes tortuous—passage is always maintained from the pit to the outside solution. If after 72 hours the sheet is cleaned by dilute acetic acid, the corrosion is seen to have been almost entirely confined within the original hydroxide walls. (Fig. 6.)

Contrary to the usual assumption that the location of the pits can be correlated with some definite property of the surface, Captain Bengough is positive in his statement that neither the original holes, artificial holes or scratches can be associated with these halos. That their location is dependent on factors external to the metal is demonstrated by Figs. 7, 8 and 9, which show the same piece of cast zinc after suspension in distilled water, lengthwise, sidewise and after having been immersed and spun horizontally. Corroded streaks of this sort have been observed microscopically during formation, and are caused by toppling halos of zinc hydrate moved in definite directions by gravity or water currents. Thus the arrangement of pits is determined mainly by the *distribution of the products* of earliest corrosion.

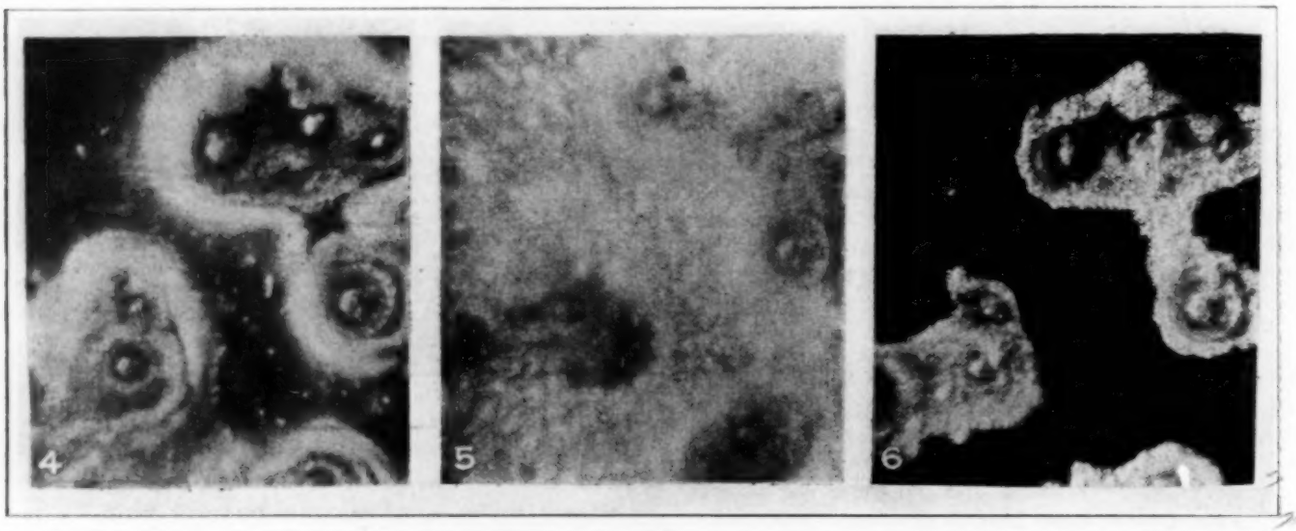
It has also often been stated that the corrosion of

[2] Distilled water was shown in the third report to attack zinc four times as fast as sea water.

metal by water is similar to acid attack—i.e., consists of hydrogen replacement. However, no evolution of hydrogen can be seen (under 400 magnifications) in distilled water, although 1:5000 acetic acid, which removes zinc at the same rate, produces very small hydrogen bubbles. In acids which pit, hydrogen appears to be evolved in the pit itself, and not at some distant cathode. Experiments with gas-free water seem to show that oxygen is an essential, and CO_2 is an accelerator of corrosion. It is inferred that oxygen does not act as a depolarizer of electrochemical action, since there is no water-line attack when zinc is partially immersed in distilled water, and from the fact that the addition of a powerful depolarizer like potassium bichromate actually retards corrosion of zinc.

Weighing all the evidence, the authors postulate that before immersion the zinc has had opportunity of acquiring a layer of oxide or basic carbonate, and its adherent and uniform layer of tarnish which is acquired by specimens not specially prepared. Such a coating can apparently be formed only by direct oxidation of the copper.

After 3 months' immersion a clean piece of electrolytic copper will retain portions of its surface-tarnish intact, where the underlying metal has not corroded. But this gelatinous tarnish is soluble to a very slight extent in distilled water, and is converted slowly to a darker porous mass, overlying shallow pits where "autocorrosion" has started. The whole mass of oxide in this vicinity becomes very loose, and even flakes off. Later some of the oxide or metallic copper in solution is changed in nature and is precipitated as crystalline Cu_2O, which persists almost indefinitely. Eventually all oxides tend to blacken. If the loose secondary oxide is dissolved in HCl it is found to analyze 80 per cent Cu, and when this factor and determinations of copper



FIGS. 4 TO 6—CAST ZINC SUSPENDED HORIZONTALLY IN DISTILLED WATER. OBLIQUE ILLUMINATION. × 70
Fig. 4—24 hr. after immersion. Fig. 5—72 hr. after immersion. Fig. 6—After cleaning with acetic acid.

further history depends upon the action of the corroding solution on this coating.* Dilute acids dissolve it, and zinc then may replace some hydrogen from the acid. Water with CO_2 in solution does dissolve the coating slowly, taking Zn into solution as bicarbonate and penetrating the surface layer at some points. Here an unknown oxide (peroxide?) is formed by the oxygen in solution reacting with the bare metal. This is highly transparent, gelatinous, non-adherent, and is an accelerator of corrosion. It is carried outward, is converted to ordinary hydroxide or basic carbonate slowly, in which condition it becomes more opaque, insoluble and protective to the metal upon which it lodges.

Oxidation of Copper in Water

Action of distilled water on electrolytic copper is much slower than on zinc, but many experiments led Dr. Bengough and his collaborators to the conclusion that here again the variations to be observed in corrosion experiments depend upon the differences in the resisting power of the first-acquired tarnish film rather than differences in the underlying metallic structure. Bright polished copper, as well as specimens annealed and cooled in hydrogen and immersed without coming in contact with air, remain bright for 2 months and lose weight at an almost vanishing rate, but when removed and dried show the acquisition of the same thin, in solution is applied to loss-of-weight experiments, remarkably consistent rates of corrosion are shown up to 160 days, as follows:

Cast copper in stagnant distilled water loses 1.7 mg. per sq.dm. per day.
Copper foil in stagnant distilled water loses 1.7 mg. per sq.dm. per day.
Arsenical copper in running distilled water loses 1.7 mg. per sq.dm. per day.
Cast copper in running distilled water loses 3.3 mg. per sq.dm. per day.

One piece of evidence that the oxidized film has determining influences lies in the fact that immersion in 1 per cent NH_4Cl (which has forty times the solubility for cuprous oxide as has distilled water, and also dissolves oxygen readily) causes rapid general corrosion of electrolytic copper without a trace of pitting. No tarnish film is formed, or it is dissolved as rapidly as formed, and the metal remains bright. Electrolytic action at anodic areas is an extremely rare occurrence. Indeed, the phenomena described above occur, but at a slower rate, when the copper is maintained cathodic by an applied e.m.f.

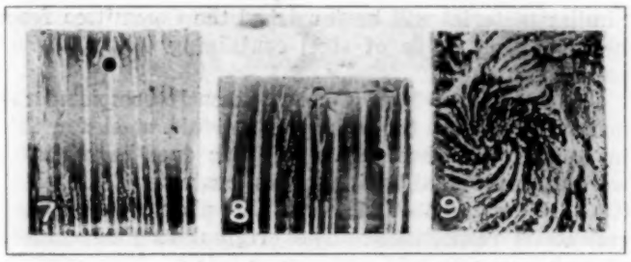
Stagnant and aërated sea water corrode copper in the same way, differing only in degree. The metal is first covered by a continuous film of cuprous oxide; in about 7 days a crystallized salt forms on the surface and then flakes off, often carrying the underlying

oxide with it. Bare metal thus exposed is apparently different from a polished surface, for it is a seat of rapid corrosion rather than a generator of a resistant membrane.

General Thinning of Brass

If a smooth piece of cast 70:30 brass be immersed in cold sea water, both the copper and zinc are oxidized immediately to form a superficial membranous tarnish. Constituents of this layer react slowly with the solution, forming basic carbonates and chlorides, mostly detached. This second reaction is slow, consequently the oxide layer gradually increases in thickness; it is also preferential, so that the oxide layers become rich in copper. However, the coating overlies yellow brass, so the corrosion is general, and eventual failure would be by general thinning, but very far distant in normal sea water.

Rapid thinning is essentially a fresh-water phenomenon, and is associated with the presence, at some time, of dilute solutions of free acid or alkalis. Thus, the



FIGS. 7 TO 9. CAST ZINC IMMERSED 24 HR. IN DISTILLED WATER. HALF SIZE

Fig. 7—Suspended lengthwise. Fig. 8—Suspended sidewise
Fig. 9—Rotated horizontally

fifth report recounts experiments on twelve different kinds of tubes immersed in 30 parts HCl per million, renewed daily. Action started from the cut edges and at pin spots, undercutting the protective surface layers and peeling them off in large flakes by the formation of oxysalts *in situ*, laying the bare metal open to direct acid attack. All surface protection is thus rapidly lost, the brassy, crystalline surface appears slightly roughened and is covered with a thin reddish layer of copper and copper oxides. From 2 to 4 per cent of thickness may be lost in 6 weeks immersion in this weak acid, an amount which tubes in favorable sea water service may exhibit after 18 years.

Temporary acidity is only slightly less dangerous. A little acid entering the condenser would perforate the protective scale and surface layer at some point where it is thin or interrupted by slag or a "draw," and then, even if the water was neutral thereafter, the resulting depression would provide a lodgment for oxides, salt or other bodies, known to cause accelerated "deposit" attack—of which more later. It is therefore most important to prevent the entrance of acid by continually maintaining the circulating water alkaline with lime water or sodium carbonate solution to the extent of 10 to 15 parts per million.

Attack by Deposits

We have thus led up to a consideration of the principal cause of deterioration in brass condenser tubes: regional corrosion or pinhole pitting caused by accelerated attack underneath adhering deposits.

It has already been noted that brass condenser tubes of commerce possess a copper-rich surface layer, containing more or less oxide. Also that the first action of corrosion is upon a thin oxidized coating rather than upon the underlying metal. Now, if a piece of smooth copper be immersed in chloride solutions, the oxidized surface gradually changes into an almost insoluble cuprous chloride (CuCl), which ordinarily is swept away by gravity or by water currents, but which may adhere to the surface. In the latter case the cuprous chloride becomes oxidized according to the reaction

$$4CuCl + O \rightarrow Cu_2O + 2CuCl_2$$

into cuprite crystals and the very corrosive, soluble cupric chloride. Sometimes, instead of crystalline cuprite, colloidal green salt is formed,[3] which is very adherent and prevents the outward diffusion of cupric chloride. It is easily proved that cupric chloride is very corrosive to copper in a wide variety of concentrations, according to the reaction

$$Cu + CuCl_2 \rightarrow 2CuCl$$

and the end product is where we started from. Therefore these reactions recur in a cycle at spots underneath gelatinous salts permeable to oxygen in solution.

Brass in chloride solutions acts similarly. As noted before, the first attack gives a layer of copper oxide, plus a little zinc oxide, the zinc mainly going into solution as $ZnCl_2$. Reactions on the copper oxide then proceed as outlined just above; if the insoluble chlorides adhere to the surface cupric chloride is formed. Cupric chloride attacks zinc as well as copper,

$$CuCl_2 + Zn \rightarrow ZnCl_2 + Cu$$

with the formation of soluble zinc chloride and the deposition of crystalline or powdery copper.

Some zinc oxide is formed in the original membranous coating. It is slowly dissolved in salt solutions, and in the presence of carbonates may be precipitated as a white basic chloride or a green double salt with copper. If these materials adhere to the metal as crystalline plates they are distinctly protective; if they are flocculent they cause pitting by trapping the corrosive cupric chloride.

This is a general statement of the mechanism of all severe corrosion of brass in sea water. Pitting is seen to be due to a product of corrosion held in place by a deposit of some sort; the location of the pits is a matter of chance. Coke particles, clinkers, sand from various sources, pieces of glass, and even massive flakes of ferric hydrate or a piece of string all act in the same way. Electrochemical action is distinctly secondary; wherever these foreign matters find lodgment they form eddies in which cuprous chloride can lodge. Later, thick deposits of bright red cuprous oxide, ruby cuprite and greenish and white basic salts accumulate. These break away on reaching a certain size, often taking with them a tiny slab of underlying metal, exposing the crystalline structure underneath in a crater which speedily fills with corrosive substances.

Furthermore, water-line attack is only a special case of "deposit" attack, doubly dangerous since the deposit forms under especially favorable conditions. Contrary to common report, it occurs as severe irregular local action up to 2 cm. *above* the water line, where the above described salts have crystallized. These corroded spots are always connected with the water by a continuous moist band acting like a capillary tube.

[3] Hydrated basic cupric chloride, corresponding to atacamite, $CuCl_2.3CuO.4H_2O$. Ordinarily the sea water contains some CO_2 or bicarbonates, which enter atacamite, turning its color somewhat blue. This circumstance slows down the subsequent reaction, but does not change its nature.

Apparent Dezincification

A great deal of space in the fifth report is given to evidence that the so-called dezincification commonly observed in corroded tubes is never caused by preferential solution of the zinc, but always to redeposition of copper from cupric chloride solution by metallic zinc. Thus: if a piece of brass is made cathodic to iron in normal $CuCl_2$ solution for 14 days, it will be found on microscopic examination that the original metal has been reduced about 10 per cent, but the total thickness of the cathode has been increased 30 per cent. This difference is soft, coherent, ductile copper; whatever crystals are observed are of a different nature than the brass structure. The bulk of this copper must have been redeposited, but the outermost portions appear to be identical with the innermost, where any dezincification surely must have been proceeding, and where the residual copper should be powdery or pseudomorphic after brass crystals. Lacking any observable difference in appearance, and since the outer portion must have been deposited, the inner portion is also assumed to have been likewise deposited.

Prevention of Corrosion

Since rapid corrosion of brass in sea water is due to some phase of "deposit" attack, the obvious remedy is to prevent the adherence of deposits or the accumulation of sediments. This seems to be the principal virtue of the so-called electrolytic methods of protection—as mentioned earlier in this review, the current builds up and maintains a layer of $CaCO_3$ which is so smooth as to prevent lodgment effectually.[4] All foreign matter could evidently be kept out of the condenser water by adequate screening, or if it is suspected that solids have entered, the condenser should be thoroughly cleaned at the first opportunity. Eddies within the tubes themselves where air pockets form and induce "water line attack" can only be avoided by correct design.

Protective coatings of oxysalts, insoluble sulphide or lead are very interesting possibilities. Pre-oxidized tubes have been favored by many engineers. As a matter of fact an oxidized layer formed by low or high temperature annealing will only protect the underlying metal for a very moderate time—perhaps three months is required for the solution of these artificial layers. A premonition of what can eventually be done with certain protectors, however, was discovered when investigating so-called "plug dezincification." It was found that one lot of sea water which had been transported in galvanized iron barrels would not produce this type of action on specimens known to be susceptible, even after prolonged immersion at 50 deg. C. The water was found to contain 0.08 g. Zn per liter. Ordinary sea water to which a corresponding amount of zinc chloride had been added was also found impotent to cause "plug dezincification." Apparently a low concentration of zinc at the surface of the metal changes the physical character of the corrosion product, since this type of corrosion is set up by a colloidal precipitate of zinc oxychloride and carbonate, and since brasses containing more than 35 per cent zinc are immune (the precipitate being visibly crystalline, instead of a colloidal salt acting like a semi-permeable membrane).

[4] It is clear that if this method of protection is to be used, it should be in operation when the condenser first receives water —local action once started can be stopped with great difficulty.

Investigation of Effect of Sulphur in Steel Progressing

Tests to determine the effect of sulphur on rivet steel made at Watertown Arsenal and the U. S. Naval Experiment Station under the direction of the Joint Committee on Investigation of Effect of Phosphorus and Sulphur in Steel (American Society for Testing Materials) have been entirely completed.

The second group of residual sulphur material in this series comprises plate and structural steels, carbon 0.16–0.22 per cent, with sulphur ranging from 0.03 to 0.08 per cent. Four heats of basic open-hearth steel with sulphurs of 0.04, 0.05, 0.06 and 0.07 on ladle analysis have been made for the Joint Committee by the Cambria Steel Co. The heats run: C, 0.20–0.25; Mn, 0.42–0.46; P, 0.01–0.02. The complete history of each heat is known. After a suitable top discard, plates were rolled as follows from each heat:

Six pieces shear mill plate.....20 x 96 x ⅜ in.
Six pieces shear mill plate....15 x 96 x ⅜ in.
Three pieces universal mill plate 20 x 96 x ⅜ in.
Six pieces universal mill plate..15 x 96 x ⅜ in.

Similar material will be furnished the Committee from heats of this grade of steel containing 0.03 and 0.08 per cent sulphur.

The Bethlehem Steel Co. has recently completed the manufacture and fabrication of certain steel for this investigation. Three heats of basic open-hearth steel were manufactured having carbon contents of 0.18–0.22, 0.35–0.45 and 0.65–0.75, typifying plate, forging and rail steels respectively. The original sulphur content of each heat was 0.04 per cent or below. Iron sulphide was added during pouring, so that for each carbon content there were secured eight ingots with "added" sulphur contents from 0.04 to 0.15 per cent. Material from the 24 ingots has been furnished for test in the form of 1-in. rounds and in flats approximately 4 x 1 in. in dimension.

In order to compare the effects of "added" and "residual" sulphur, available scrap from three low-sulphur ingots of each heat was remelted, producing steel with "residual" sulphur of approximately 0.08 per cent; and three of the higher sulphur ingots from each heat were remelted, producing steel with residual sulphur of approximately 0.13 per cent. This material will also be fabricated in the form of rounds and flats for tests.

Regulations on Sale of Alcohol

The Internal Revenue Bureau has issued a warning that denatured alcohol offered for sale must be advertised and marked as denatured or completely denatured alcohol, with a poison label, and not simply as "alcohol."

It is charged that persons who sell denatured alcohol at retail frequently advertise that "alcohol" is for sale, without any qualifying words such as "denatured" or "completely denatured," in violation of section 17 of the national prohibition act and section 97 of regulations 60. It is charged that such retailers also frequently sell completely denatured alcohol without placing on the container thereof the cautionary "Poison" label required by article 108 of regulations 61.

Inasmuch as such illegal practices menace the health and lives of persons who might be misled into believing that the alcohol is pure, parties guilty of such practices are warned to discontinue them immediately. Violations will be reported to the United States Attorney for prosecution.

The German and American Synthetic-Ammonia Plants*—II

Comparison of the Methods of Manufacturing Hydrogen and Nitrogen at Oppau, Germany, and at Sheffield, Ala.—Differences in Processes for Supplying Nitrogen—Construction and Operation of the Carbon-Monoxide Converters

By R. S. TOUR

THERE are, in reality, four distinct types of gas produced at Oppau: (1) Water gas made from coke, as the main source of hydrogen for the synthesis of ammonia, (2) lean gas as the main source of nitrogen for the ammonia, (3) power gas (producer) as the main source of power throughout the plant, and (4) nitrogen from liquid air for adjustment of gas composition in the synthesis of ammonia. These gases and gas mixtures are generated according to standard methods and in standard equipment.

Water-Gas Production at Oppau

The water gas and lean gas are made in 12-ft. shell Pintsch type generators of which there are 15, 12 with, and 3 without, revolving grates. In addition there are two or three experimental generators where an attempt is being made to develop a lignite burning water-gas machine, and a slagging type producer. The fuel used is a high grade of coke normally to be delivered from byproduct coke ovens on the grounds. These ovens are to have a capacity of 700 tons of coke per day, the excess gas from which may be used for power purposes.

The water-gas machines deliver about 2,500,000 cu.ft. each per day (at 60 deg. F. and 30 in. Hg) with a fuel consumption of 40 to 42 lb. per thousand. The normal operating capacity of the water-gas machines is 25,000,000 to 30,000,000 cu.ft. per day, with a coke consumption of 550 to 650 tons. The generators are operated on one- to two-minute "blows" and three- to five-minute "runs," the latter being "up," "down," or "mixed," according to requirements. The steam used is 175 lb., 125 deg. F. superheat. The water-gas consumption is approximately: 4 per cent CO_2, 43 per cent CO, 49 per cent H_2 and 4 per cent N_2. Attention is called to the fact that a high nitrogen content is not objectionable here since there is to be a later admixture of high nitrogen gas. Any steps tending to decrease the loss of hydrogen in the stack, however, are desirable.

The lean gas (producer gas made from selected fuel) consists merely of water gas to which is added the blast gas of the blow period. This allows of continuous, rather than intermittent, operation of the machines producing this gas. In the water-gas machines the blast gas volume is nearly twice the water gas generated. Thus the capacity of the machine producing lean gas is about 7,000,000 cu.ft. per day, with a fuel consumption of about 15 lb. per thousand. The lean gas required is about half the water gas; hence two generators supply the necessary capacity and consume some 100 tons of coke per day, coke being used to produce a methane-free gas. The lean gas composition is approximately 5 per cent CO_2, 30 per cent CO, 15 per cent H_2 and 50 per cent N_2.

*For Part I see CHEM. & MET. ENG., vol. 26, No. 6, p. 245, Feb. 8, 1922.

The water gas and lean gas pass separately through standard wash-boxes and water scrubbers packed with Rauschig rings and on to two water-gas storage and relief holders of 500,000 cu.ft. capacity each, and one lean gas holder of like size. There are no purifiers for the gas and no waste-heat boilers on the machines.

Manufacture of Producer Gas

Producer gas (power gas) is made according to standard procedure in twenty-three B.A.M.A.G.[4] continuous producers with revolving grates. These are situated in the same building with, and in a row directly opposite, the water-gas machines mentioned above. The machines are of 16-ft. shell diameter and burn a fuel of part lignite briquets (cylindrical 2 in. by 4 in. in diameter) and part hard coal, the latter being advisable for maintaining good fuel bed conditions and producer capacity. The producers deliver about 2,500,000 cu.ft. per machine per day, with a fuel consumption of 20 to 22 lb. per thousand (at 60 deg. F. and 30 in. Hg). This gives a plant capacity of about 50,000,000 cu.ft. per day and a daily fuel consumption of about 500 tons.

In view of the high combustion rate for the type of fuel in the producers, a low steam proportion is used, a high fuel bed temperature is maintained and the gas made is high in nitrogen and of low heating value. A mean composition would be 4 per cent CO_2, 27 per cent CO, 4 per cent H_2, 2 per cent CH_4, and 63 per cent N_2. The purification of the producer gas is naturally more extensive than that of the water gas. First, a standard water scrubber is used, followed by a centrifugal water washer or tar extractor and a cyclone separator. The clean gas then passes to a

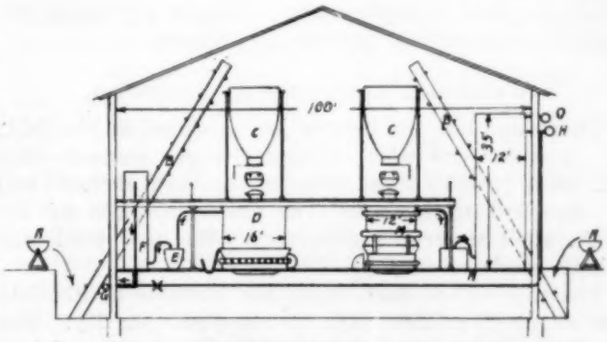


FIG. 2. PRODUCER AND WATER-GAS GENERATORS AT OPPAU

A. Cars for lignite and coke.
B. Conveyors.
C. Hoppers and charging buggies.
D. Power-gas producer.
E. Hydraulic main.
F. Water scrubbers.
G. Main to power-gas holder.
H. Main to lean-gas holder.
M. Water-gas generator.
N. Wash box and water scrubber.
O. Main to water-gas holders.

[4]Berlin Anhaltische Maschinen Aktien Gesellschaft.

2,000,000-cu.ft. holder feeding the gas engines throughout the plant.

Production of Pure Nitrogen

Free nitrogen is necessary for incidental purposes about the plant and large quantities are essential for continuous adjustment of the composition of the hydrogen-nitrogen mixture required for the synthesis. The mixing of the water gas, described above, with the lean gas yields a mixture somewhat low in nitrogen and purposely made so, since nitrogen in variable quantities in the form of air is to be later added for internal combustion and heat maintenance. The variation in this combustion air, as well as operating variations in gas compositions and in proportioning of lean gas to water gas, may lead to quite wide variation from the 3:1 hydrogen-nitrogen mixture finally required for ammonia synthesis. Since any slight excess of either constituent rapidly accumulates in the ammonia-synthesis circulating system where the ammonia removed represents exactly three parts hydrogen to one part nitrogen, it becomes necessary continuously to adjust the composition of the gases. It is obvious that this adjustment is more economically made by adding pure nitrogen rather than pure hydrogen, and hence the initial gas mixture is purposely maintained sufficiently low in nitrogen to allow for more than the subsequent operating variations.

The nitrogen plant at Oppau consists of 6 distillation columns of the Linde type and 7 air compressors direct-connected to gas engines. The installation was old and a new plant has been built similar to the above and having a capacity of about 1,800,000 cu.ft. of nitrogen per day. If half of this capacity is regularly used for adjustment of composition, it represents about 13 per cent of the nitrogen fixed and allows for an average nitrogen deficiency of 3 per cent of the total gas mixture entering the ammonia synthesis system.

The water gas, as a source of hydrogen, and lean gas, as a source of nitrogen, are delivered from their respective holders by turbo-exhausters equipped with water injectors for saturating the gas and followed by cyclone separators for removing excess water. The gases then pass through meters and to a mixing main equipped with turbo-blowers for mixing the gas and for feeding it to the converter system. The two gases are fed to the mixing main in such proportions as finally to yield a purified gas, which, as previously explained, is somewhat deficient in nitrogen.

Water-Gas Production at Sheffield

There was but one type of gas produced at Sheffield: viz., a water gas with varying nitrogen content—this gas being produced according to standard methods and in standard equipment. The latter consists of six 7½-ft. shell water-gas generators; the fuel used was a high grade of coke.

The capacity of each water-gas machine at Sheffield was about 0.7 million cu.ft. of water gas per day. The plant capacity was about 3,500,000, or about sufficient for the rated ammonia capacity. However, the contemplated operation called for a number of gas-fired furnaces in conjunction with the process and had their use not proved unnecessary, the gas plant would have been much under capacity. The water gas from the machines passed through standard wash boxes and water scrubbers and on to a storage and relief holder of 500,000 cu.ft. capacity. From this the gas was fed by holder pressure through iron-oxide purifying boxes on the way to the carbon-monoxide converters. The purifiers caused some trouble due to excessive friction and were soon found to be unnecessary. It will be noted that the Germans did not use any purification process.

Methods of Supplying Nitrogen

The plant had been designed to operate on a high-nitrogen water gas where all the nitrogen necessary for the later synthesis was injected as air into the generator during the gas-making period. This method, although generating a mixed gas, is not fundamentally different from the procedure used at Oppau, though the former may be more adaptable for small plant use. In either case, the nitrogen comes from blast gases and the air used has made available heat within the fuel bed. Where possible, it is naturally more desirable to operate one of the machines as a continuous producer and the other machines for straight water-gas production. The Sheffield plan of using only part of the blowing air in each machine simultaneously with steam during gas production involves many operating difficulties, the most important of which is the variable composition of the effluent gases. Although both the air and the steam can be measured, the proportion of steam

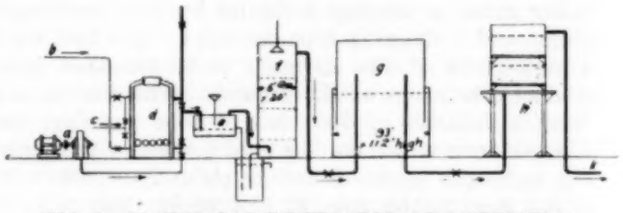


FIG. 3. WATER-GAS GENERATOR AT SHEFFIELD

a. Sirrocco blower, motor driven.
b. Auxiliary air inlet to gas generator.
c. Steam inlet to gas generator.
d. Water-gas generator.
e. Wash box.
f. Scrubber.
g. Holder.
h. Iron-oxide purifier.
k. Gas exit to CO converter.

decomposed, and therefore the resultant proportion of hydrogen, will be dependent upon the grade of fuel, upon the temperature and cleanliness of the fuel bed, and upon operating variables in general, and will also vary enormously from the beginning to the end of each "run."

It was found that later in the process very considerable air injection into the carbon-monoxide converters was required for internal combustion and maintenance of temperature, and this reduced the quantity of nitrogen the mixed gas might carry from the water-gas machines. In view, therefore, of the difficulties in operating the gas machines and the actual low nitrogen content desired, the final operation at Sheffield developed into straight water-gas manufacture with all of the nitrogen added later by air injection. The latter type of operation, although it may be necessary, is fundamentally inefficient, since air injection into the gas with combustion of the latter involves a definite loss of hydrogen or carbon monoxide (later yielding hydrogen), whereas the nitrogen available from the gas generator blast represents no loss of fuel. Complete nitrogen supply by air injection and combustion in the gas involves a loss of 25 per cent of the hydrogen obtainable from a given volume of water gas with

NITROGEN SUPPLY BY AIR INJECTION AND COMBUSTION

	Pure Water Gas (Cu.Ft.)	After Combustion of 333 Cu.Ft. of Air With CO (Cu.Ft.)	After Combustion of 333 Cu.Ft. of Air With H_2 (Cu.Ft.)	After CO Conversion (Cu.Ft.)	Analysis (Per Cent)
Carbon dioxide	40	177	40	449	29.2
Carbon monoxide	440	303	440	31	2.0
Hydrogen	520	520	383	792	51.6
Nitrogen	....	264	264	264	17.2
	1,000 Cu. Ft.			1,536 Cu.Ft.	100.0

NITROGEN SUPPLY BY BLAST-GAS ADDITION

	Pure Water Gas (Cu.Ft.)	After Adding 514 Cu.Ft. Blast Gas (Cu.Ft.)	After CO Conversion (Cu.Ft.)	Analysis (Per Cent)
Carbon dioxide	40	61	601	29.2
Carbon monoxide	440	581	41	2.0
Hydrogen	520	520	1,060	51.6
Nitrogen	...	352	352	17.2
	1,000 Cu. Ft.		2,054 Cu. Ft.	100.0

nitrogen added as blast gas, and thus increases the fuel consumption by 33 per cent.

The results given in the preceding tables have been calculated on the basis of identical operation and efficiency in each case. It is to be noted that it makes no difference whether carbon monoxide or hydrogen is burned by the air in the first case; values are, however, given for both.

During operation at Sheffield the blue water gas produced had the approximate composition: 4 per cent CO_2, 44 per cent CO, 50 per cent H_2, and 2 per cent N_2. The coke consumption was about 60 lb. per thousand cubic feet, and the labor charge high. A high fuel and labor charge is to be expected in view of the small size of the machines. After the close of plant operation, the Nitrate Division tried an improvement on the machines with great success. This consisted mainly of secondary blast within the fuel bed, allowing more rapid and uniform heating during the blow and improving the fuel efficiency by reducing carbon-monoxide losses in the blast gases. Test showed that the fuel consumption had been reduced to 40 lb. of coke, or equally as good as the German operation with their 12-ft. machines.

There was no pure nitrogen produced at Sheffield for adjustment of composition. Experience with the control of the nitrogen content, however, proved that had the plant produced any quantity of ammonia, adjustment of composition would have been necessary. Thus, had the hydrogen to nitrogen ratio been 3.3 to 1.0 (and that is not bad operation) rather than 3.0, capacity operation within three or four hours would have caused the ratio in the ammonia synthesis system to reach 5 to 1.

Carbon-Monoxide Conversion at Oppau

The mixture of lean gas and water gas after being proportioned properly has the approximate composition: 4 per cent CO_2, 39 per cent CO, 38 per cent H_2, and 19 per cent N_2. This mixed gas has added to it a large excess of steam and passes through heat interchangers to the converter where a catalyst aids the exothermic water-gas reaction: $CO + H_2O \leftrightarrows CO_2 + H_2$. The converted gas passes back through the heat interchangers followed by a condenser to remove excess steam.

The steam addition at Oppau is accomplished by an apparatus which we may call a steam interchanger, whereby much of the steam condensed from the converted exit gas is made available to the inlet mixed gas. This cooling and condensation of exit gas is brought about by direct contact with a counter-current spray of cold water in a condenser shell 12 ft. in diameter and 60 ft. tall, filled with suitable packing. The water emerges from the bottom of the condenser at nearly boiling temperature and is fed to the vaporizer, similar in all respects to the condenser, where the cold inlet gas is heated and supplied with steam from the hot water. The water is cooled by this treatment and again repeats its cycle through the condenser.

Two sets of steam interchangers handle the entire plant capacity, interchanging some 1,400 tons of steam per day per pair. The total steam required for the nearly 40,000,000 cu.ft. of inlet mixed gas is about 4,000 tons (i.e., 4 volumes per volume of inlet gas), 300 tons of which actually react, and an additional 1,000 tons of which are not interchanged but lost as condensate. The 2,700 tons that are interchanged to the inlet gas are augmented by 1,300 tons of low pressure steam injected into the mixture just before it enters the converter system.

Path of Gases

There are 24 converter sets, complete with heat interchangers, 12 sets in each of two adjacent buildings. All sets are fundamentally the same and have a capacity of about 75,000 cu.ft. of dry inlet gas per hour. In each building the sets operate in parallel, taking inlet gas and steam from a single main and discharging to one main. The path of the gases in each set is through a large interchanger followed by a small one, which raise the gas temperature to some 500 deg. C. when it passes through the carbon-monoxide catalyst, there further rising in temperature about 60 deg. C. due to reaction heat. All but about 3 per cent of the carbon monoxide in the gas is converted at this point. The gas then passes back through a second catalyst bed at a lower temperature, at the entrance to which air is injected and, if necessary, additional steam. The carbon monoxide is here reduced to 1.5 per cent and the gas passes on through the last heat interchanger.

The heat interchangers consist of large sheet-iron shells with an internal nest of tubes; the inlet gas passes around the tubes and exit gas through the tubes. This path is by far the better, since the external radiation losses are decreased, as well as the temperature transfer head improved. The larger interchanger is about 6 ft. in diameter by 30 ft. high, while the smaller is 6 ft. by 20 ft. high. Both shells are lagged with about 8 in. of magnesia.

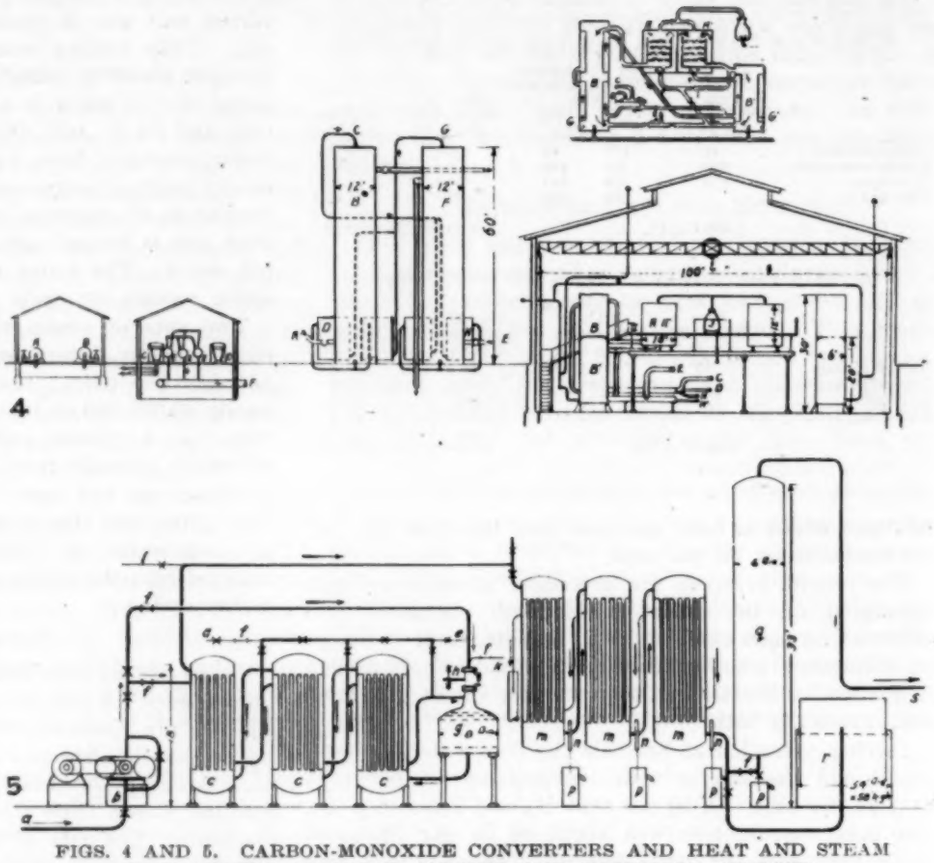
The Catalyst Beds

The two catalyst beds are in a heat-insulated shell about 12 ft. tall. A horizontal cross-section of the shell would be rectangular (10 ft. by 30 ft.) with round corners. A vertical partition divides the shell into two independent compartments. The catalyst in each compartment is placed on five superposed trays all within a container to conduct the gas downward through the catalyst.

The use of two catalyst beds in series, the second at a lower temperature, represents a decided improvement in operation. The water-gas reaction, as well as the later ammonia reaction, has a much more favorable equilibrium at lower temperatures, but also a much slower reaction rate. Thus, it is desirable to accomplish most of the reaction at higher temperature and

follow that by low temperature catalysis. If air or oxygen be available during low temperature catalysis, the oxidation of the carbon monoxide will be much more readily carried to its equilibrium value. Further, the air supply may be adjusted to supply internal heat within the system, if such be necessary for maintenance of temperature. The catalysts used for the carbon monoxide conversion depend for their activity mainly upon iron oxide with chromium oxide as a promoter. Cerium and thorium oxides have also been tried as promoters.

Great care is taken in the control of the converters. Each set is supplied with some 50 base-metal thermocouples reading on an indicating millivoltmeter. There are manometers to read pressures in different parts of each set and Pitot tubes to measure flow of steam and gas and air. The gas obtained at the exit of the converter sets has the approximate composition: 29.5 per cent CO_2, 1.5 per cent CO, 53 per cent H_2, and 16 per cent N_2. The volume of inlet gas has been increased about 35 per cent in the converters, so there is a daily converted gas production of 50,000,000 to 60,000,000 cu.ft. (representing 25,000,000 to 30,000,000 cu.ft. of hydrogen). This converted gas, after condensation of moisture, passes back to the metering house where the inlet gas was measured and mixed. After the gas has been metered, it passes to another 500,000-cu.ft. holder, from which it is directly available to the compressors.



FIGS. 4 AND 5. CARBON-MONOXIDE CONVERTERS AND HEAT AND STEAM EXCHANGERS AT OPPAU (ABOVE) AND SHEFFIELD (BELOW)

Fig. 4 (above).

Meters and Mixers at Oppau (at left).
A. Gas exhauster from water-gas holder.
B. Gas exhauster from lean-gas holder.
C. Gas meters to mixers.
D. Gas meters for converted gas.
E. 3 turbo ventilators for mixing.
F. Mixed gas discharge main to steam interchanger.

Steam Interchangers at Oppau (center).
A. Cold raw gas mixture.
B. Heating and evaporating tower.
C. Hot water inlet to *A*.
D. Cold water reservoir from *A* and feeding to *G*.
E. Hot converter gas inlet.
F. Cooling and condensing tower.
G. Cold water inlet to *F*.
H. Hot water reservoir from *F* and feeding to *C*.

Carbon-monoxide Converter and Heat Interchangers at Oppau (at right).
A-A'. Catalyzers.
B-B'. Large and small heat interchangers.
C. Raw gas inlet.
D. Steam inlet.
E. Converted gas and steam exit.
F-F'. Auxiliary air and steam injection.
G-G'. Nitrogen inlet for flushing.
H-H'. Flushing exit.
I. Main control valve for by-passing small interchanger.
J. Starting burner using producer gas.

Fig. 5 (below). Carbon-monoxide Converter, Heat Exchangers and Condensers at Sheffield.
a. Gas inlet from holder.
b. Connersville blowers, motor driven.
c. Heat exchangers.
d. Steam inlet to heat exchangers.
e. Hot air inlet for starting system.
f. Venturi meters.
g. Catalytic chamber.
h. Auxiliary burner (on catalytic chamber).
k. Air inlet to burner.
l. Gas vent from system.
m. Condensers.
n. Separators.
p. Overflow.
q. Buffer tank.
r. Gas holder.
s. Gas exit to compressors.

Carbon-Monoxide Conversion at Sheffield

The conversion process used at Sheffield was much the same as that at Oppau, especially so toward the close of operation. The gas from the holders was delivered to the converter set by positive pressure exhausters. No steam interchangers were used, but all the steam, 200 lb. per thousand cubic feet of gas (about 4 volumes per volume of inlet gas) was fed from the steam main and all the excess steam on the exit gas was condensed. This method of operation requires about three times as much steam and condensing water as does the method described for Oppau. The steam supply, as the plant was installed, was to feed through a standard gas-fired tubular steam superheater which was to furnish the additional heat required to maintain the converter system at operating temperature. This method of heat supply is inefficient in two ways: (a) The steam superheater efficiency is directly involved and this is low, especially for the large superheat required at Sheffield, and (b) heating the inlet mixture decreases the temperature head across the heat interchangers and their heat transfer is proportionally decreased. On the other hand, air injection for internal combustion of gas at the catalyst chamber yields nearly 100 per cent thermal efficiency and also increases the temperature head across the interchangers, thus improving their heat transfer. After burning out the steam superheater, the internal-combustion method was tried with great success and with a large saving in gas consumption. The steam then was injected as low pressure steam.

The condensation of the excess steam at the exit of the system was accomplished by two surface condensers operating in parallel. These were soon found to be of only a fraction of the necessary capacity and additional condensers were installed. Very little experience is available for the design of condensers for a mixture of 75 per cent steam and 25 per cent gas. Some experiments made by the Nitrate Division looking toward the redesign of the condensers indicate that the coefficient of heat transfer under such conditions is of the order of one-tenth that in standard condensers. The actual value, however, is largely dependent upon the lineal velocity of flow of the steam-gas mixture and of the water. Efficient condensation at the exit of the carbon-monoxide system is important, especially if the mixture passes on directly to the compressors, as it did at Sheffield. The condensate is of no value, due to dissolved gases, and the only reason for using surface, instead of jet condensers, would be to make use of the heated cooling water.

Operation at Sheffield

There was but one carbon-monoxide converter set with a rated capacity of 30,000 cu.ft. of inlet gas per hour, in the operating unit. (Unit No. 1.) This consisted of one catalyst chamber with three heat interchangers, the inlet gas passing through the first and smallest of the three before steam injection. The general construction of the interchangers was much the same as that described for Oppau, although with much less transfer surface. The heat transfer through the interchangers was not very satisfactory and accounted for the fact that the system was so far from self-maintaining in temperature.

There was but one catalyst chamber, of circular section, 8 ft. in diameter and 6 ft. deep, into which was first charged 120 cu.ft. of catalyst in a single bed about 2½ ft. deep. In operation this bed rapidly developed high friction to gas flow, due to crumbling and packing of the catalyst, which is physically delicate and can not withstand the accumulated friction and weight of a deep bed. The converter was repacked with about half the depth and operated quite satisfactorily thereafter, although the Oppau method of placing the catalyst in shallow layers on superposed grids is the best solution.

During operation the catalyst inlet temperature was maintained at 500 deg. C. and the rise in temperature across the catalyst bed was 50 to 60 deg. C. As mentioned before, this heat liberated was far from sufficient to maintain the system at its proper temperature and air was injected for internal combustion at the top connection of the converter through what was known as the auxiliary burner. The air combined with the gas as a flame above the catalyst and not within the catalyst bed. Flame combustion is the better method where any large quantity of heat development is necessary since it prevents too large a temperature gradient through the catalyst bed itself. No provision had been made for ignition of the auxiliary burner, but this difficulty was soon overcome. The more flame used, the more nitrogen is added and the less is to be introduced at the gas house.

Operation at Sheffield required that about 75 per cent of the total nitrogen be added at the burner and finally, in view of the difficulty of nitrogen control in the gas machines, all of it was added through the burner, the excess heat developed being wasted by partly bypassing the heat interchangers.

No secondary converter was used at Sheffield, although the writer, without being acquainted with the process in use at Oppau, tried experimentally in November, 1918, what he called an "oxidizer" in the converter set of Unit No. 2 (not the one in operation). The oxidizer was merely an additional converter connected in the line of the return gas from the primary converter after the gas had passed through one heat interchanger. The oxidizer was charged with the same catalyst as the primary converter, operated at a lower temperature than the latter, and had air injection, but not through a burner, oxidation being desired within the catalyst. For various reasons the experiment was not continued long enough to give decisive data. However, the standard operation at Oppau is somewhat similar to that attempted with the "oxidizer."

During operation, temperatures were measured by 4 or 5 platinum resistance pyrometers; pressures were indicated by manometers in the system; and gas, steam and air inlet volumes were measured by Venturi meters. The converted gas composition was about 29 per cent CO_2, 3 per cent CO, 51 per cent H_2, and 17 per cent N_2; the residual carbon monoxide was about the same as at the first catalyst exit in Oppau, although the nitrogen was higher, since no further nitrogen addition was contemplated. The converted gas passed directly from the condensers to the compressors, a Venturi meter on the line measuring the compressor intake. In the suction line to the compressors was connected a larger buffer tank to absorb the pulsations and also a 75,000-cu.ft. holder to take up the slight variations between supply and demand.

(*Part III will appear in a subsequent issue.*)

Manufacture of Soap in Brazil

Some interesting facts relative to the soap industry in Brazil are presented in the Feb. 6, 1922, issue of *Commerce Reports*.

Brazilian companies are able to turn out all of the laundry and cheap house soap required in that country, using as a basis the fats and greases obtained in their immediate neighborhood. A great many types of toilet soap are also being produced, and although it is said that Brazil is independent from outside sources for goods of this nature, it is admitted that the foreign product is superior to the native goods.

The chemicals required, including rosin, soda ash, coloring matter and perfumes, must all be imported. Rosin comes exclusively from the United States, while England has had almost a monopoly on the soda trade.

The yearly importation of soda averages 10,000 tons, which makes it a business well worth striving for. It was thought a few years ago that recently formed domestic companies would be able to supply the local market, but with the resumption of free trade in this material after the war, it was found that the domestic product was more expensive than the imported, and this at once killed all prospects of local competition.

The finer materials, including essential oils and coloring matter, play a comparatively small part in the soap-making industry, and European houses have been able to get practically all of the business up to the present time.

To compete successfully for this business, active agents, stock for immediate delivery and attractive prices are essential.

Manufacture of Synthetic Cast Iron in the Electric Furnace

Synthetic Iron Produced in the Electric Furnace on the Pacific Coast—Detrimental Effects of Excessive Dry Slags—Comparative Costs of Manufacture for Various Load Factors

By W. L. MORRISON, E. M.

THE MANUFACTURE of synthetic cast iron, so called to distinguish it from the blast-furnace product, has been carried on in various parts of this country and abroad.

The opportunity for research in connection with the manufacture of synthetic iron and the melting of cast iron in the electric furnace is very great.

The first work on synthetic pig iron in Portland, Ore., was started in the summer of 1918. The furnace used was one which had been operating on ferromanganese, being of the three-phase, stationary type, with open top, three 17-in. electrodes being used. The furnace had an electrical capacity of 600 kw. Before starting on the pig iron a 9-in. arch was placed on the furnace with water-cooled bronze bushings for the electrodes. The ends of the arch were left open for charging the furnace.

In the latter part of 1919 a 2-ton furnace of the stationary type was installed for the production of gray iron castings from turnings and steel. The shell is 7 ft. wide, 11 ft. long and 6 ft. high, made of ¾-in. boiler plate reinforced with ship channel. A tap hole was cut in the side of the shell about 12 in. in diameter; a few inches below this main tap hole a 3-in. hole was cut to be used should the bottom be lower at any time than could be drained from the upper hole. The shell was set on I-beams on a concrete foundation, of such height as to allow a 5-ton buggy ladle to pass under the spout. A charging platform was erected at either end of the furnace on the same level as the top of the furnace, to facilitate charging, which was done under the arch at the ends.

The furnace was supplied with electric current by three Acheson graphite electrodes 8 in. in diameter operated by the so-called hand controls. Current was received at 11,000 v. and stepped down to 70 v., using three Packard Electric Transformers, 250 kva. each, the transformers being delta connected. The transformers were of the outdoor type, installed in the open without covering, and no trouble was experienced during the rainy seasons.

Furnace Linings

The side walls of the furnace were lined with highest grade firebrick to a thickness of about 18 in. The furnace bottom was made up with 8 in. of firebrick and 12 in. of rammed coke dust and tar. Between the firebrick and the shell 1 in. of asbestos cement was used for heat insulation. The asbestos insulation gave excellent results, as the furnace shell remained cool enough to hold one's hand on it even during continuous operation.

The carbon bottom lining gave quite satisfactory results, but was troublesome to repair on account of having to warm the coke and tar mixture and ram into place in a hot furnace; furthermore, the supply of fine coke was limited and there was no economical means of pulverizing more. The furnace bottom was repaired weekly without interrupting the operation during the week. The linings lasted from 6 to 8 weeks, operating one and two shifts. The metal poured was free from blow-holes, but at first somewhat low in carbon, as the carbonizer used was all anthracite coal; by operating with a larger excess of coal the carbon content was brought up. The first furnace bottom had to withstand very rough usage on account of considerable experimental work with different carbonizers and fluxes.

After the first 6 weeks of operation the carbon bottom was abandoned and a silica bottom substituted. This was made up of silica rock crushed to about ¼ in., silica sand and about 10 to 15 per cent high-grade fireclay and brickbats. The silica bottom was repaired every 2 weeks, sometimes weekly, depending on conditions. Under normal conditions the bottom gave very satisfactory results.

Furnace Bottom

In order to eliminate the repairs to the furnace bottom it was suggested to use a solid firebrick bottom. A high-grade firebrick was obtained and, when repairing the side walls, a brick bottom was placed in the furnace to a depth of 13 in. in addition to the 8-in. firebrick lining already in. The upper course was stood on end to prevent the brick from floating; hytempite cement was used to bond the brick, but after several days' operation some of the brick began to float, and upon examination it was found that about half the brick had been dissolved by the metal. The furnace was drained and repaired, the brick bottom being removed and a rammed silica bottom substituted. While removing the old brick bottom it was noticed that the iron had run in between the brick and become lens shape due to the action on the brick. Analysis of these specimens showed that silicon and aluminum had been absorbed. Analysis of lens shape mass showed silicon, 5.1 per cent; aluminum, 1.25 per cent. Analysis of iron produced showed silicon, 2.25 per cent; aluminum, 1.12 per cent. The aluminum is high in the iron on account of the iron absorbing it from the brick bottom; iron made on the silica bottom had less than 0.1 per cent Al.

In the long run the silica bottom appeared to give the most satisfactory results both as to operation and quickness of repairs. The repairs were usually made at the end of the week and required 2 to 4 hours.

The arch of the furnace was made up of 9-in. wedge firebrick giving a spring of 15 in. in the 7 ft. An opening was left in the ends approximately 20 in. wide for charging and stirring the metal. Brick-lined doors were fitted to the openings and supported by chains on pulleys and balanced by weights. Bronze water-cooled bushings were fitted in the roof where the electrodes entered the furnace. The usual life of the lining and arch operating two shifts was 2 months.

In the operation of the 2-ton furnace smelting turn-

ings and borings, the most efficient operation was obtained by continuous charging and tapping at regular intervals. In this way the light materials were preheated before reaching the melting zone. The furnace was fed about every 30 minutes and tapped at intervals of 2 hours.

After thoroughly drying and baking the furnace lining, 200 or 300 lb. of anthracite coal is charged on the bottom, then, if turnings and borings are used, these are charged along with the requisite amounts of coal, silicon, manganese, lime and spar. When using the continuous method it is desirable to weigh up small charges—i.e., 500 to 1,000 lb. A representative charge would be: 500 lb. turnings, 50 lb. anthracite dust, 20 lb. 50 per cent ferrosilicon, 2 lb. 80 per cent ferromanganese, 5 lb. lime and 2 lb. spar. By using small charges the silicon and manganese are more evenly mixed with the turnings, and a more uniform product is obtained.

The first question naturally to be asked is, Can the metal be produced hot enough by continuous charging? The writer has never known of a cold heat by this method of operation using turnings and borings, except when the electric power failed for several hours.

If it is desired to run heavy scrap such as burned grate bars or steel scrap, this heavy scrap is added immediately after tapping, the electrodes being raised to prevent breakage. The continuous method can be used only with the small light scrap, or so-called shoveling scrap, the silica, coal, etc., being added with the scrap.

About every 2 days the entire charge in the furnace is completely melted to permit the accumulated slag to be removed. The slag is in the form of crusts and is removed by means of a long-handled fork.

In making pig iron the slag has to be eliminated more often than when making iron for use direct in castings, because more lime is required for the sulphur removal. When melting cast borings and steel turnings without lime flux the sulphur content of the metal rarely exceeds 0.07 per cent provided the cast scrap does not exceed 50 per cent of the charge. There is a loss of sulphur of from 0.01 to 0.03 per cent during the melting without lime additions.

Carbonizing

The carbonizing of the iron is very simple if the carbonizing material is finely divided ($\frac{1}{2}$ in. and smaller), and used in excess.

The first attempts at carbonizing were very discouraging, because the materials used were all large size. Charcoal was first tried but not with very satisfactory results. The charcoal was of about 4 in. average size, being used just as it came from the pit. The electrode would arc in time on the charcoal and would not heat the metal nor carbonize it, the result being cold metal and low carbon (2.80 to 3.00). Coke breeze was next tried with somewhat better results, but the excessive ash and the fact that coke up to 2 in. was in the breeze made this material undesirable. Finally, a few tons of anthracite dust of slack was obtained from a ferromanganese smelter and tried. The first attempt was not very promising, but upon larger additions being made, a carbon content up to almost any desired amount could be attained. The ash in the anthracite coal ran about 5 per cent, while that in the coke ran as high as 25 per cent.

Charcoal was then crushed and found to be equal and in some ways superior to anthracite coal, but on account of the excessive cost of charcoal and having no facilities for crushing, anthracite coal was adopted for carbonizing. The relative cost and value of different carbonizers is given below:

Material	Ash, per Cent	Fixed Carbon, per Cent	Cost per Ton
Anthracite coal	5.0	88.00	$11.00
Charcoal	2.5	76.00	28.00
Coke	21.00	67.00	14.00
Coke	14.00	75.00	18.00

After a series of experiments it was found that a complete and even carbonization could be effected by operating with a cover of coal of from 4 to 6 in. over the metal. This perhaps explains why the continuous method of charging works so successfully with the light scrap. During operation the coal is in a state of incandescence, and the molten iron filtering down through this hot mass of fine coal is carbonized completely due to a combination of high temperature and large exposed area.

The metal is maintained at a white heat due to the hot bed of coal directly over it, the coal separating the semi-fused and cooler scrap from the molten metal. Samples were taken at the beginning and finish of a tap and the analysis was found to be very uniform.

When making gray iron for direct use in the foundry care must be used not to have too high a carbon content and a separation of graphite in the molds. In case the preliminary sample shows an excess of graphite, this can be cut by adding a few hundred pounds of steel scrap. When the excess graphite begins to show in the castings, it is best to cut down the amount of coal in the charge, or omit it altogether from a few charges.

Should it be desired to make a lower carbon iron, or so-called semi-steel, only a small amount of carbon should be added, then if the fracture appears too low the carbon may be raised by adding more coal and boiling the metal with a green pole, or by boiling without the coal addition, as sufficient coal is usually on the bed to completely carbonize when boiling is resorted to. When making the lower carbon irons it is more desirable to run single charges and melt down the entire charge before tapping, as better control of the carbon may thus be had.

An all-steel scrap charge gives a better iron of low carbon content (3.00 per cent) than can be had from cast borings or a mixture of cast iron and steel, being freer from impurities and lower in phosphorus. The iron made from an all-steel scrap mix is very fluid and has plenty of "life," even more than iron of similar analysis from the cupola.

In the production of pig iron one does not need to be so careful about the high carbon content. Pig iron running 3.75 to 4.25 per cent total carbon is readily made in a furnace operating with a thick bed of the proper size material and the right voltage between phases (60 to 75 volts).

In order to see what the cupola could accomplish in the way of carbonizing, a charge of 500 lb. of boiler scrap was run through the cupola along with the requisite amount of lump ferrosilicon. The iron produced was close grained but machined readily. The analysis of the iron produced from boiler punchings in the cupola is as follows:

	Per Cent		Per Cent
Combined C	0.96	Mn	0.35
Graphite C	2.02	P	0.04
Total C	2.98	S	0.08
Si	2.54		

This metal did not have the fluidity that metal of

similar analysis tapped from the electric furnace, although both appeared to have about the same temperature at the time of tapping. The cupola metal set very quickly after being poured in the mold and left a small skull in the ladle. The metal was sound and free from blow-holes. The electric iron made from boiler punchings was very fluid and set slowly in the mold; it poured like oil from the ladle, leaving no skull.

Basic Slag

Lime is added to the charge for the sole purpose of lowering the sulphur content in the finished metal. The addition of lime has been found necessary only when making pig iron to specifications, the high limit ranging from 0.03 to 0.05 per cent sulphur. The basic slag was run on a carbon bottom, also on a silica bottom. One reason why the basic slag worked so well, using an acid furnace, is due to the fact that a very heavy bed of coal held the slag and kept it out of contact with the side walls of the furnace. As a matter of fact, the side walls at times had a tendency to build up with accumulation of slag crust, and spar would have to be added in increasing amounts to cut the slag from the side walls. The iron filtering through the bed of coal and basic slag is both cleansed and carbonized at the same time.

When using lime it is best to add some spar to prevent the lime from entering the metal. Lime under certain conditions appears to have a very deleterious effect upon cast iron, due no doubt to the concentrated heat of the arc-forming carbides of calcium which are absorbed to a greater or less extent by the iron at existing temperatures unless the calcium carbide is in such dilution in the slag by the aid of spar as not to be readily absorbed. The proper control of temperature also aids in preventing the absorption.

The effect of calcium compounds in cast iron is very similar to that produced by aluminum carbide; the iron on being poured has the appearance of burned iron if the total carbon content is not above 3.45 per cent. The iron when poured in green sand molds has a tendency to develop blow-holes beneath the skin of the metal.

However, if the total carbon content is above 3.50 per cent, a very good cast can be made, but the iron does not have the life of ordinary iron. If the total carbon content exceeds 3.65 per cent, with calcium compounds present, the iron, upon cooling somewhat, becomes sluggish with separation of graphite on the ladle, lumps like large marbles separate out and are readily distinguished when pouring; these lumps break up and appear to be mostly graphite with small amount of slag. At times the ladle of 200-lb. capacity would suddenly start an accumulation of graphite and upon trying to skim this off it was found impossible to do so, and it would have to be pigged. The total carbon on these heats rarely exceeded 3.75 per cent and yet the metal would have 1 to 3 in. of graphite covering it. While this high-carbon metal appeared sluggish, the melting point was very low as compared with ordinary iron.

Effect of Aluminum Upon Cast Iron

The effect of aluminum upon cast iron is pretty well known and has been widely discussed; but the effect of carbides of aluminum upon cast iron has been given little attention.

The subject was brought quite forcibly to the writer's notice when the melter was having trouble with his heat, operating with too heavy a slag, and in trying to raise the carbon content additional slag would be formed from the roof and side walls due to the excessive heat; when the metal was finally poured, if the carbon was under 3.25 per cent, the iron would give the appearance of burned iron, producing blow-holes under the skin of the metal when poured in greensand. No lime was used in these heats referred to. Sometimes the metal would purge from the molds when poured into heavy work. Under similar conditions with iron high in carbon, the castings would be free from blow-holes, but would not be as fluid when poured as metal made under the proper conditions. A scum was noticeable over the metal and would continue to form after being lifted off by the skimmer, otherwise the metal lay quiet in the ladle and to all appearances was good iron. The results noted were very similar to those produced by a dry basic slag.

When the trouble was first experienced, increased amounts of silica were added to see if the blow-holes could be eliminated, but even with silicon up to 4 per cent and carbon 3.00 to 3.25 per cent the blow-holes still persisted. Analyses of various irons showed the aluminum content to run from 0.4 to 1.25 per cent. Upon the addition of water to the borings from these bad heats gases were evolved much more readily than from turnings from other heats.

High Temperature Effects Aluminum Content in Iron

The writer believes that with the intense heat produced by the arc and in the presence of aluminous bearing materials such as the firebrick in large excess, carbides of aluminum are formed and absorbed at the high temperatures as the iron passes through the coal mass. These same aluminum carbides, being very energetic chemically, react with the moisture in the molds and produce the gas holes, giving the appearance of the so-called burned iron.

In cupola practice bad iron often results from the use of cheap fireclays, or running the cupola excessively not, accumulating aluminous slag, which, if not properly fluxed, reacts with the coke; especially if the temperature is very high due to high blast pressure and contracted area in coke bed, the iron may absorb aluminum carbide and produce the so-called burned iron. The writer has noticed that from the same ladle of cupola iron a dry mold casting would be perfectly sound, while a greensand casting would develop blow-holes under the skin of the casting.

A small experiment made by the writer in the East upon the action of vanadium thermit in cast iron recalls a condition which tends to cast light upon the action of aluminum or aluminum carbide on cast iron. A mixture of vanadium oxide and 90 per cent silicon was made into a capsule and placed in the bottom of a 200-lb. ladle, the iron was poured on the capsule—the reaction taking place reducing the vanadium—and was then poured into a greensand mold; the casting was perfectly sound. A second ladle was poured, placing the same size capsule on top of the molten iron in the ladle. After the reaction the iron was stirred and poured into greensand mold, and good casting resulted. All together six ladles were poured using the 90 per cent silicon vanadium mixture in varying amounts and good iron resulted every time.

The experiments were repeated, using aluminum-vanadium oxide thermit mixture, and in every case the iron upon being poured into greensand purged upon standing or developed blow-holes upon machining the casting. Thinking that perhaps the theoretical amount

of aluminum was not enough to give complete reduction of the oxide of vanadium, a 10 per cent excess was added, then increased to 25, and finally double the theoretical amount was added, and in every case blowholes developed. The iron to all appearances after the thermit reaction was as good as any, not showing signs of being wild or gassing. The untreated castings from the same heat were all good. Stick aluminum was added in the last ladle after the thermit reaction, but gave no better results. Ten ounces of aluminum was added to an untreated ladle of iron and after stirring well was poured; the iron produced a sound casting, which tends to prove the iron was all right.

Comparing the results in the electric furnace with the reaction of aluminum and vanadium oxide, the conclusion reached is that the temperature produced by the thermit reaction was sufficient to form aluminum carbide in the iron, which reacted with the moisture in the sand. Aluminum carbide is very unstable and active chemically. If the gas in the iron was due directly to oxides being present on account of the vanadium oxide, then one would naturally expect the silicon mixture to give the trouble, because the heat of reaction is much less than that of aluminum with vanadium oxide.

Carl Buberl, in the July 1, 1921, issue of *Foundry*, calls attention to the fact that "cupola daubing clay affects iron." While Mr. Buberl does not say that the iron absorbs aluminum compounds, he does state that the iron absorbed something from the clay and gave poor castings. When a better grade of clay was used and less slagging encountered, the trouble was less frequent. This all tends to prove my theory regarding the absorption of aluminum carbide at high temperatures. I believe that much of the so-called burned iron from the cupola is not due to excess of oxygen absorbed or present as oxides, but is due to bad slag conditions and contamination from aluminous materials.

The only way to overcome this difficulty both in the cupola and in the electric furnace is by the proper selection of refractories, and by keeping dry aluminous slag off the metal. We have tried various additions to the ladle, also poling in the furnace with a green pole, but once the metal has been contaminated by aluminum you must either raise the carbon sufficiently high to overcome the effect of the aluminum carbide or pig the heat. In cupola practice, of course, it is impossible to raise the carbon, but with the electric furnace one has a somewhat wider range of operation.

There is an excellent field for investigation of the influence of calcium and aluminum carbide on cast iron of varying carbon content at high temperatures, such as are attained in the electric furnace.

Spar

Spar is used largely with basic slags to give fluidity, but when using basic slag on an acid bottom should not be used too freely, otherwise the acid lining is attacked and the basic slag goes over to acid slag. The usual additions of lime and spar were 15 to 20 lb. lime and 8 to 15 lb. of spar to the ton of metal melted. The thick bed of coal also aids in keeping the slag from the sidewalls of the furnace.

The sulphur content of the charge is reduced during the melting as the molten metal passes through the coal bed and basic slag. For this reason the acid-lined furnace would not work as well in the duplex process operating a basic slag, for in this case the furnace is usually not operated with a thick bed of coal which holds the slag. However, there is a possibility that a modification of this method of refining might be adopted in the duplex process and work out quite satisfactorily.

Analyses of several consecutive heats are given in Table I to demonstrate the control of the electric furnace on synthetic iron.

TABLE I—ANALYSES OF HIGH-MANGANESE PIG IRON

Heat No.	Silicon	Total Carbon	Manganese	Phos.	Sulphur
71	2.87	3.59	4.02	0.14	0.03
72	2.96	3.46	4.04	0.16	0.03
73	3.10	3.33	4.00	0.17	0.035
74	2.98	3.60	4.08	0.12	0.035
75	2.44	3.46	4.28	0.16	0.03
76	2.92	3.52	4.02	0.12	0.03
77	3.01	3.31	4.24	0.14	0.035
78	2.44	3.35	4.08	0.15	0.035
		Analyses of Foundry Iron			
97	2.54	3.42	0.58	0.14	0.035
98	2.63	3.63	0.64	0.14	0.03
99	2.87	3.59	0.66	0.16	0.035
100	2.84	3.46	0.59	0.15	0.025
101	2.89	3.67	0.77	0.15	0.03
102	2.81	3.77	0.59	0.13	0.03
103	2.85	3.62	0.66	0.15	0.035
104	2.69	3.65	0.61	0.17	0.03

The irons analyzed were all made in the electric furnace with an acid lining, using lime and spar in the charge. Furnace was operated continuous charging with about 6-in. bed of coal over the molten metal. The charge consisted of mixed turnings and borings, which accounts for some variation in the silicon content of the finished metal. Using all steel turnings, the silicon content can be held much more uniform. When an all cast boring charge is used the amount of coal needed is very much less, and this must be taken into consideration to avoid metal too high in carbon.

Comparative Cost of Electric Furnace Operation

One great drawback to an electric furnace operating intermittently is the sliding scale power rates as now existing in many localities. A furnace should be operated 16 hours a day to obtain economical operation and a good power rate. When business is slack and the foundryman is pouring a limited tonnage each week, perhaps operating less than one shift per day, he must pay a greatly increased rate besides getting a lower furnace efficiency.

For this reason a foundryman contemplating a furnace installation should figure a furnace of such capacity as to operate 24 hours when the foundry is at capacity, instead of operating only the one shift. Then when conditions arise to cut the capacity down to say 25 per cent of normal, the electric furnace can still operate practically one shift with economy.

For the sake of comparison I give in Table II comparative costs of one-, two- and three-shift operation.

Summary of Operating Costs

In summing up these figures we find the operating costs as follows:

Total cost per net ton of iron at the spout: One shift, $40.33; two shifts, $30.18; three shifts, $27.40. These figures do not include fixed charges, which vary in different plants, but are given to show the actual necessity of operating the electric furnace at least two shifts to get a desired economical operation. This does not mean that the remainder of the plant or foundry need go on a two-shift basis. The figures are based on actual opera-

TABLE II—COMPARATIVE COSTS OF ONE-, TWO- AND THREE-SHIFT OPERATION

Figures based on 2-ton furnace, 750-kw. electrical capacity

Cost of materials:		
Scrap (turnings and borings), net ton		$10.00
Power:		
1 shift, 1.25 c. kw.-hr.		
2 shifts, 1.00c. kw.-hr.		
3 shifts, 0.80c. kw.-hr.		
Coal (anthracite), net ton		15.00
Electrodes (graphite), lb.		.24
Lime (in bbl.), net ton		30.00
Spar, net ton		40.00
Silicon, gross ton		100.00
Manganese steel (12 per cent), net ton		30.00
Melting loss using tunings not rusted, 10 per cent		
Production of iron:		
1 shift, 6 tons		
2 shifts, 14 tons		
3 shifts, 22 tons		
Power consumption per ton:		
1 shift, 850		
2 shifts, 800		
3 shifts, 750		
Cost of operation one shift 8 hours		
Conversion cost:		
Power, 6 x 850 = 5,100 kw.-hr. @ 1.25c. kw.-hr.		$63.75
Materials:		
Electrodes, 6 x 15 = 90 lb. @ 24c.	$21.60	
Lime, 6 x 20 = 120 lb. @ 1.5c. lb.	1.80	
Spar, 6 x 15 = 90 @ 2c. lb.	1.80	
Coal, 200 x 6 = 1,200 lb. @ 0.75c. lb.	9.00	
Silicon, 6 x 50 = 300 lb. @ $100 ton	13.40	
Mn steel 6 x 50= 300 lb. @ 1.5c. lb.	4.50	48.90
Labor:		
1 melter @ $6	6.00	
2 laborers @ $4	8.00	14.00
Repairs and miscellaneous:		
Furnace	6.00	
Tools	3.00	
Water and miscellaneous	3.00	12.00
Total		$138.65
Conversion cost per ton, $138.65 ÷ 6		29.33
Cost of scrap @ $10 plus 10 per cent loss		11.00
Total cost net ton at the spout		$40.33
Cost of furnace operation, 2 shifts		
Conversion cost:		
Power, 14 x 800 = 11,200 kw.-hr. @ 1c.		$112.00
Materials:		
Electrodes, 12 x 14 = 168 lb. @ 24c.	$40.32	
Lime, 14 x 20 = 280 lb. @ 1.5c.	4.20	
Spar, 14 x 15 = 210 lb. @ 2c.	4.20	
Coal, 14 x 200 = 2,800 lb. @ 0.75c.	21.00	
Silicon, 14 x 50 = 700 lb. @ $100 ton	31.25	
Mn steel, 14 x 50 = 700 @ 1.5c. lb.	10.50	111.47
Labor:		
2 melters @ $6	12.00	
4 laborers @ $4	16.00	28.00
Repairs and miscellaneous:		
Furnace	8.00	
Tools	6.00	
Water and miscellaneous	3.00	17.00
Total		$268.47
Conversion cost per ton, $268.47 ÷ 14		$19.18
Scrap cost @ $10 ton plus 10 per cent loss		11.00
Total cost per net ton at spout of furnace		$30.18
Cost of furnace opera ion, 3 shifts		
Conversion cost:		
Power 22 x 750 = 16,500 kw.-hr. @ 8c. kw.-hr.		$132.00
Materials:		
Electrodes, 22 x 10 = 220 @ 24c. lb.	$52.80	
Lime, 22 x 20 = 440 @ 1.5c. lb.	6.60	
Spar, 22 x 15 = 330 @ 2c. lb.	6.60	
Coal, 22 x 200 = 4,400 @ 0.75c. lb.	33.00	
Silicon, 22 x 50 = 1,100 @ $100 ton	49.11	
Mn steel, 22 x 50 = 1,100 @ 1.5c. lb.	16.50	164.61
Labor:		
3 melters @ $6	18.00	
6 laborers @ $4	24.00	42.00
Repairs and miscellaneous:		
Furnace	10.00	
Tools	9.00	
Water and miscellaneous	3.00	22.00
Total		$360.61
Conversion cost per ton, $360.61 ÷ 22		$16.40
Scrap cost, $10 ton plus 10 per cent for loss		11.00
Total cost per net ton of iron at the spout		$27.40

tions covering several months. The average analysis of the iron made was as follows: Silicon, 2.25; carbon, 3.50; manganese, 0.65; sulphur, 0.04; phosphorus, 0.15.

Many suggestions have been offered regarding the possibility of smelting iron ore with scrap in localities where ore was available and only a limited amount of scrap. In view of present power cost, high labor cost and the fluctuating market of pig iron, this proposition appears for the present entirely out of question, as the figures in Table III will show.

TABLE III—ESTIMATED COST OF PRODUCING GRAY IRON FROM TURNINGS, BORINGS AND IRON ORE (Hematite or Limonite)

For comparison with the preceding figures we will assume a furnace of 750-kw.-hr. electrical capacity, stationary furnace of the crucible type, with arch and charging doors under the arch.

Charge to produce 2 net tons pig iron:		
1.1 tons scrap		
2.2 tons ore high grade		
80 lb. lime		
30 lb. spar		
1,400 lb. coal		
100 lb. silicon		
100 lb. Mn scrap		
Power required for scrap per ton of iron produced, kw.-hr.		750
Power required per ton iron from ore, kw.-hr.		2,200
Power required to smelt one charge producing 2 tons iron, kw.-hr.		2,950
The furnace operating on 90 per cent load factor would consume 750 x 24 x 0.9 = 16,200 kw.-hr. per 24 hours		
The number of charges run in one day or 24 hours would be 16,200 ÷ 2,950 = 5.5 charges, or a daily production of 11 net tons iron		
Conversion cost:		
Power, 16,200 kw.-hr. @ 0.8c. kw.-hr.		$129.60
Materials:		
Electrodes, 220 lb. @ 24c. lb.	$52.80	
Lime, 440 lb. @ 1.5c.	6.60	
Spar, 165 lb. @ 2c. lb.	3.30	
Coal, 5.5 x 1,400 = 7,700 @ 0.75c.	57.75	
Silicon, 5.5 x 100 = 550 @ $100 ton	24.55	
Mn steel, 5.5 x 100 = 550 @ 1.5c. lb.	8.25	
Labor (see 3-shift operation)		42.00
Repairs and miscellaneous (see 3-shift operation)		22.00
Total		$346.85
Conversion cost per net ton, $346.85 ÷ 11		31.45
Scrap cost, 1.1 tons @ $10 ton ÷ 2		5.50
Ore cost, 2.2 tons @ $5 ton ÷ 2		5.50
Total cost of iron per net ton from ore and scrap based on 3-shift operation		$42.45

Under similar operating conditions we have an iron cost of $27.40 per net ton using all scrap, as against $42.45 using ore and scrap mixed. The greatly increased power required to smelt ore cuts down the output and brings up the cost.

If it is desired to produce pig iron with a higher silicon content, it is only necessary to add to the total cost the extra expense of the silicon, which runs about $2 additional for each 1 per cent. For convenience the figures given have been for net tons.

Furnace Construction Costs

The cost of furnace construction varies with different localities, but high and low figures are given for comparison.

The figures are based on 750-kw. stationary furnace, acid lined, three phase, three electrodes, hand operated. High tension voltage, 11,000; low tension side, 70 volts, sixty cycle. Three transformers, air-cooled type.

Furnace steel work	$700.00	$900.00
Transformers and freight	3,200.00	4,200.00
Furnace lining	400.00	700.00
Foundations	250.00	300.00
Plumbing	100.00	150.00
Electrical equipment and castings	1,000.00	1,500.00
Miscellaneous	300.00	500.00
Total	$5,959.00	$8,250.00

The higher figure would cover installations of this type in the West and includes all labor, but not engineering service. While this furnace gives very good results and is especially adapted for the production of pig iron, the so-called tilting furnaces are better adapted for general casting work in the foundry, and are almost universally used for this purpose.

Flake Graphite as a Lubricant

A study of flake graphite as a lubricant is being made by the Bureau of Mines. An interesting development in connection with the graphite work is that the lower grades can be purified by the Trent process, thus rendering them suitable for lubrication purposes.

The Relation Between the Composition of Vapor and Liquor in Distillation

An Experimental Study of Some of the Fundamental Laws Governing the Distillation of Mixtures. Including the Derivation of a Number of Formulas of Use in the Solution of Practical Problems Connected With the Design and Operation of Distillation Equipment

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THERE are many in the chemical industries, especially among the younger members of operating and production departments, who are more or less unfamiliar with the basic laws of distillation. It is therefore the intention of the present paper to review some of these theoretical considerations and to show that they have an important bearing on practical problems confronting the operator, as well as the designer, of distillation apparatus.

If s is the proportion of one component in a mixture such as a gas liquor, and S the proportion of the same component in the vapor distilled from this liquor, the relation between the composition of the vapor and liquor in regard to the considered component is $k = \frac{S}{s}$

In industrial distillation, liquors are either concentrated or exhausted and in both cases the strength of the liquor passes through a number of stages of different concentration. Knowing the values of k corresponding to these different stages, we are in a better position to study the design of the distillation apparatus and to control its operation.

DETERMINING DISTILLATION CONSTANT EXPERIMENTALLY

One way in which the values of k can be obtained is to submit a relatively large quantity of liquor to distillation, taking very small fractions of the distillate, so that the composition of the liquor can be considered as constant during the distillation of each fraction. An analysis of the liquor and of the corresponding distillate will give corresponding values of s, S and k.

In Table I a distillation test on 1,000 c.c. of ammonia liquor, as obtained by coal distillation, is given as an example. It will be noted that the value of k varies with the strength of the liquor.

OBTAINING THIS VALUE BY CALCULATION

On the other hand, in distillation problems we need an ideal or average constant value of k, which, when applied to the problem, will give a result conforming to the actual. This ideal value of k can be found by the following method.

Suppose we distill out of a quantity Q of liquor, containing a proportion s of a component, an infinitesimal quantity dQ. The proportion of the same component in the distillate at the beginning of the distillation is S, at the end $S - dS$. The average strength of the distillate is $S - \frac{1}{2}dS$, while the quantity of the component we have in the distillate is $(S - \frac{1}{2}dS)\,dQ$.

During the distillation, the proportion of the component in the liquor changed from s to $(s - ds)$, the quantity remaining in the liquor after distillation being $(Q - dQ)\ (s - ds)$.

Hence the relation

$$Qs - (Q - dQ)\ (s - ds) = (S - \tfrac{1}{2}dS)\,dQ$$

which gives, after neglecting the differentials of the second order,

$$\frac{dQ}{Q} = \frac{ds}{S - s}$$

or, if the initial quantity of liquor was Q_o:

$$\log_e Q_o - \log_e Q = \int_{s_o}^{s} \frac{ds}{S - s}$$

If $\frac{S}{s} = k$ (constant), then

$$\log_e Q_o - \log_e Q = \frac{1}{k - 1}\,(\log_e s_o - \log_e s)$$

or

$$\left(\frac{Q_o}{Q}\right)^{k-1} = \frac{s_o}{s} \qquad (1)$$

which gives the desired value of k.

For instance, according to the distillation test given in Table I, we have

$$Q_o = 1{,}000 \qquad Q = 500$$
$$s_o = 7.72 \qquad s = 0.006$$

hence

$$\left(\frac{1{,}000}{500}\right)^{k-1} = \frac{7.720}{0.006}$$

$$k - 1 = \frac{\log_e 7.72 - \log_e 0.006}{\log_e 2} = 10.3$$

$$k = 11.3$$

This value of k, applied to distillation operations where the concentration of the ammonia liquor of the quality given above varies from 7.72 to 0.006 g. per liter, will give results corresponding with those actually obtained.

There are, however, instances in which it is not so easy to find the value of k—that is, cases where the pro-

TABLE I—DISTILLATION TEST ON 1,000 c.c. OF AMMONIA LIQUOR

Liquor in Distillation				Distillate			
Quantity, c.c.	Volatile Ammonia g. Total	Volatile Ammonia g. per Liter	Aver.	Quantity, c.c.	Ammonia g. Total	Ammonia g. per Liter	$\frac{S}{s}$
1,000	7.7200	7.7200					
				25	1.7660		
975	5.9540	6.1060	5.835				
970	5.4960	5.5630		5	.4580	91.590	15.7
				70	3.7110		
900	1.7850	1.9830	1.915				
895	1.6462	1.8470		5	.1388	27.762	14.5
				95	1.1727		
800	0.4735	.5920	.575				
795	0.4431	.5570		5	.0304	6.086	10.6
				95	.3056		
700	0.1375	.1950	.191				
695	0.1302	.1870		5	.0073	1.4625	7.6
				95	.0892		
600	0.0410	.0680	.066				
595	0.0380	.0640		5	.0030	.6120	9.3
				95	.0350		
500	0.0030	.0060					

There are, however, instances in which it is not so easy to find the value of k—that is, cases where the pro-

portion of the considered component cannot be readily determined by chemical analysis, as happens, for instance, with mixtures of components of the same organic group. In such cases the following method will often give fair results.

Laws Applicable to Mutually Soluble Mixtures

In industrial practice, such mixtures consist generally of components of one chemical group which dissolve perfectly one in the other and respond very nearly to the relation

$$a_{1\times 2} = \sqrt{a_1 \times a_2}$$

where $a_{1\times 2}$ represents the mutual attraction of the unlike, and a_1, a_2 the mutual attraction of the like molecules.

Under such conditions, the following general laws can be applied:

(1) The partial vapor pressure of each component equals the product of the vapor pressure p of the same component considered separately, multiplied by the molecular proportion m of the said component in the mixture.

(2) The vapor pressure P of the mixture equals the sum of the partial vapor pressures of the components:

$$P = p_1 m_1 + p_2 m_2 + \ldots .$$

(3) The molecular proportion M of a component in the vapor is in ratio with the partial pressure pm of same component in the mixture:

$$\frac{M_1}{m_1 p_1} = \frac{M_2}{m_2 p_2} = \ldots . \qquad (2)$$

These two relations give:

$$\frac{M_1}{m_1 p_1} = \frac{M_2}{m_2 p_2} = \ldots . \quad \frac{M_1 + M_2 + \ldots .}{m_1 p_1 + m_2 p_2 + \ldots .} = \frac{1}{P} \qquad (3)$$

and consequently the relation k' between the molecular proportions of each component in the vapor and in the liquor is:

$$k' = \frac{M}{m} = \frac{p}{P}$$

in which p is the vapor pressure the investigated component (considered separately as a pure liquor) would have at the temperature of the mixture, and P the pressure under which the distillation is made.

If we consider the proportions in weight S and s of a component in the vapor and in the liquor respectively, we have further:

$$\frac{S_1}{M_1 \text{ mol}_1} = \frac{S_2}{M_2 \text{ mol}_2} = \ldots . = \frac{1}{M_1 \text{ mol}_1 + M_2 \text{ mol}_2 + \ldots .}$$

$$\frac{s_1}{m_1 \text{ mol}_1} = \frac{s_2}{m_2 \text{ mol}_2} = \ldots . = \frac{1}{m_1 \text{ mol}_1 + m_2 \text{ mol}_2 + \ldots .}$$

where "mol" represents the molecular weight of the component.

This introduced in the relation (2) gives:

$$\frac{S_1}{p_1 s_1} = \frac{S_2}{p_2 s_2} = \ldots . = \frac{1}{p_1 s_1 + p_2 s_2 + \ldots .}$$

and

$$k = \frac{S}{s} = \frac{p}{p_1 s_1 + p_2 s_2 + \ldots .}$$

But the use of this relation is not as easy as that of the relation (3), because $p_1 s_1 + p_2 s_2 + \ldots .$ is not equal to the pressure P and must be calculated whenever the proportion of the components in the liquor is altered.

When we go further into the question, we see that the knowledge of k' given by the expression

$$k' = \frac{p}{P}$$

presupposes the knowledge of p (the vapor pressure of the pure component at the temperature of distillation of the mixture) with a degree of exactness we cannot find, in general, through the information we have available concerning vapor pressures.

Compensating for Differences in Vapor Pressure

For instance, for benzene, we find, according to different authors, vapor pressures varying as follows:

Temperature, Deg. C.	Vapor Pressure, Mm. of Hg
50	272.1 to 268.9
60	393.0 to 380.5
70	554.2 to 548.2
80	756 to 755
90	1,018 to 1,016
100	1,335 to 1,344
110	1,740 to 1,748

If we take the pressures shown in the third column and given by the Bureau of Longitudes of Paris,[1] as being the more correct, we still find considerable divergence from the calculated values. First, we note that the pressure 380.5 mm. should be 389.5 mm. Then, making the differences between this pressure and that of the vapor pressure at 50 deg. the first difference, and making the second difference the spread between the first differences, and then continuing the process to the third difference, we obtain the following values:

Vapor Pressures Mm. of Hg	First Difference	Second Difference	Third Difference
268.9			
	120.6		
389.5		38.1	
	158.7		10
548.2		48.1	
	206.8		6.1
755		54.2	
	261		12.8
1,016		67	
	328		9
1,344		76	
	494		
1,748			

As vapor pressure increases according to natural laws, it is evident that the third difference should vary uniformly, at least as long as no disturbing phenomena are met. The reason it does not vary uniformly is that the indicated pressures are not absolutely correct, but are located sometimes above, sometimes below, the real curve of pressures. We must therefore try to locate a uniform and more correct curve between these pressures. Values for such a curve can be obtained empirically after a few trials, and we derive the following table:

Temperature, Deg. C.	Corrected Pressure, Mm. of Hg	First Difference	Second Difference	Third Difference
50	268.9			
		120.6		
60	389.5		38.5	
		159.1		8.8
70	548.6		47.3	
		216.4		8.8
80	755		56.1	
		262.5		8.8
90	1,017.5		64.9	
		327.4		8.8
100	1,344.9		73.7	
		401.1		
110	1,746			

These values appear to correspond very closely to the reality.

Within the small range of temperatures used in distillation and using a constant third difference as a basis we can derive an expression which will give us a scale of temperatures sufficiently accurate for most purposes.

This is not absolutely general, but the practical results obtained by this method are more accurate than any other results based on experience.

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[1] Annuaire du bureau des longitudes de Paris. Données physiques.

This scale of pressures is constructed as follows:

Third Difference	Second Difference	First Difference	Vapor Pressure	Row
			a	1
		b		
	c		$a+b$	2
d		$b+c$		
	$c+d$		$a+2b+c$	3
d		$b+2c+d$		
	$c+2d$		$a+3b+3c+d$	4
d		$b+3c+3d$		
	$c+3d$		$a+4b+6c+4d$	5
		$b+4c+6d$		
			$a+5b+10c+10d$	6

where the expression of the pressure is given by the following equation:

$$p=a+b\frac{n-1}{1}+c\frac{n-1}{1}\times\frac{n-2}{2}+d\frac{n-1}{1}\times\frac{n-2}{2}\times\frac{n-3}{3}+\ldots.$$

This equation, when applied to the table already given for the vapor pressures of benzene, would give

$$n=\frac{t-40}{10}$$

$$p=268.9+120.6\frac{t-50}{10}+\frac{38.5}{2}\times\frac{t-50}{10}\times\frac{t-60}{10}+\frac{8.8}{6}\times\frac{t-50}{10}\times\frac{t-60}{10}\times\frac{t-70}{10}$$

or

$$p=-64.6+6.58t-0.9715t^2+0.001466t^3$$

But the use of this equation is difficult and it would be more convenient to have a table of pressures varying from degree to degree. In order to prepare such a table, we can make use of the quantities A, B, C, D, calculated from the equations:

$$D=\frac{d}{1{,}000};\ C=\frac{c-900D}{100};\ B=\frac{b-45C-120D}{10};\ A=a$$

Applying these to the data for benzene, we obtain:

$$A=268.9$$
$$B=10.5783$$
$$C=0.3058$$
$$D=0.0088$$

and vapor pressures as shown in Table II.

Knowing the vapor pressures of benzene, we can readily find the temperatures at which the other members of the benzene group have the same vapor pressure, by applying the law of proportion of absolute temperatures at equal pressures:

$$\frac{T_1}{T_2}=\frac{T'_1}{T'_2}$$

For instance, we have at a pressure of 760 mm. of mercury:

Boiling point of toluene.... 110.4 deg. C.
Boiling point of benzene.... 80.2 deg. C.

$$\frac{T_{tol}}{T_{ben}}=\frac{273+110.4}{273+80.2}=1.0855$$

which will give the corresponding temperatures for toluene as indicated in Table II.

Once we have derived, by this method or any other, a sufficiently complete and correct table of the vapor pressures of the components, we can easily find the values of

$$k'=\frac{p}{P}$$

We have, for instance, for benzene and toluene in mixture boiling at the following temperatures, under a pressure of 760 mm. of mercury:

Temperature, Deg. C.	Benzene	Toluene
80.2	$k'=1.000$	$k'_2=0.385$
81.8	1.050	0.409
83.7	1.112	0.438
85.75	1.182	0.478
88.1	1.267	0.506
90.75	1.368	0.553
93.8	1.492	0.608
97.2	1.640	0.677
101.0	1.818	0.758
105.3	2.036	0.863
110.4	2.320	1.000

In this case, as with ammonia liquor and almost any other mixture, k is variable. Sometimes, however, we are able to find an ideal constant value of k as was done for ammonia liquor, by a similar method. Knowing the composition of the final liquor we want to obtain, we find its boiling temperature with the help of our tables of vapor pressures. Then we can make a distillation test on the original liquor and note the quantity of residue that is left, when the temperature reaches the boiling temperature of the final liquor. With this value Q, and the composition of the original and final liquor s_0 and s, equation (1) will give the average value of k.

More often, however, such a distillation test will not give us any definite result. The purpose of industrial distillation, in general, is to separate almost pure products out of a mixture, and when we distill a sample of the mixture in the laboratory the whole liquor often distills over before the temperature reaches that of the component supposed to remain as residue. The reason is that for these mixtures the value of k is too near to unity and the evacuation of the more volatile components proceeds so slowly that only a quantity of residue, too small to be estimated, remains in the flask. But for liquors distilling according to the laws previously mentioned, if we cannot find the ideal constant value of k by experience, we can calculate it.

We have seen before that

$$\log_e Q_0-\log_e Q=\int_{s_0}^{s}\frac{ds}{S-s}$$

The values of this integral if determined graphically are the surfaces located between the x-axis, the curve $y=\frac{1}{S-s}$ and the values of s_0 and s. Suppose this value is N and we have

TABLE II—CORRECTED VAPOR PRESSURES FOR BENZENE AND TOLUENE

Benzene Temp., Deg. C.	Toluene: Vapor Pressure, Mm. of Hg	Toluene: Pressure Difference per Deg. C.	Toluene: Temp., Deg. C.	Benzene: Temp., Deg. C.	Benzene: Pressure Difference per Deg. C.	Benzene: Vapor Pressure, Mm. of Hg
50	268.9	9.8	77.6	80	23.6	755.0
51	279.5	10.0	78.7	81	24.1	778.6
52	290.4	10.3	79.8	82	24.7	802.7
53	301.6	10.6	80.9	83	25.4	827.4
54	313.1	10.9	82.0	84	25.9	852.8
55	324.9	11.2	83.0	85	26.5	878.7
56	337.1	11.6	84.1	86	27.1	905.2
57	349.7	11.9	85.2	87	27.8	932.3
58	362.6	12.2	86.3	88	28.4	960.1
59	375.9	12.5	87.4	89	29.0	988.5
60	389.5	12.9	88.5	90	29.7	1,017.5
61	403.5	13.3	89.6	91	30.3	1,047.2
62	418.0	13.6	90.6	92	31.0	1,077.5
63	432.8	14.0	91.7	93	31.7	1,108.5
64	448.0	14.4	92.8	94	32.3	1,140.2
65	463.7	14.8	93.9	95	33.1	1,172.5
66	479.8	15.2	95.0	96	33.7	1,205.6
67	496.3	15.6	96.1	97	34.5	1,239.3
68	513.3	16.0	97.2	98	35.2	1,273.8
69	530.7	16.5	98.2	99	35.9	1,309.0
70	548.6	16.9	99.3	100	36.6	1,344.9
71	567.0	17.3	100.4	101	37.4	1,381.5
72	585.8	17.8	101.5	102	38.2	1,418.9
73	605.2	18.2	102.6	103	38.9	1,457.1
74	625.0	18.7	103.7	104	39.7	1,496.0
75	645.3	19.2	104.8	105	40.5	1,537.5
76	666.2	19.7	105.8	106	41.2	1,576.2
77	687.6	20.2	106.9	107	42.1	1,617.4
78	709.5	20.7	108.0	108	42.8	1,659.5
79	732.0	21.2	109.1	109	43.7	1,702.3
80	755.0		110.2	110		1,746.0

$$\log_e Q_o - \log_e Q = N$$

which, combined with equation (1), gives

$$k = 1 + \frac{\log_e s_o - \log_e s}{N}$$

This value of k will then take the place of its variable values in our distillation problems.

Application to Distillation Problems

For instance, we take a mixture containing 80 per cent of benzene and 20 per cent of toluene from which we wish to extract the benzene until only 0.5 per cent is left in the residue of toluene. Suppose these percentages are molecular proportions for which we have to use the expression $\frac{1}{M - m}$ instead of $\frac{1}{S - s}$. We calculate first, with our tables of pressures, the values of M and $\frac{1}{M - m}$ for different values of m, in order to construct the curve $y = \frac{1}{M - m}$ with sufficient exactness between the values $m_o = 0.8$ and $m = 0.905$.

We find, for instance, that the mixture of 80 per cent benzene and 20 per cent toluene under a pressure of 760 mm. of mercury boils at 84.45 deg. C., since at this temperature

$$p_1 m_1 + p_2 m_2 = 692 + 68 = 760$$

and further, that

$$M = \frac{mp}{P} = \frac{692}{760} = 0.91$$

which, combined with $m = 0.8$, gives

$$\frac{1}{M - m} = \frac{1}{0.11} = 9.091$$

The following table and diagram (Fig. 1) are based on this calculation:

m	M	$\frac{1}{M-m}$	m	M	$\frac{1}{M-m}$
0.80	0.91	9.091	0.20	0.374	5.763
0.70	0.854	6.506	0.10	0.2072	9.328
0.60	0.789	5.277	0.06	0.1300	14.286
0.50	0.711	4.737	0.04	0.08873	20.500
0.40	0.620	4.553	0.02	0.04530	39.516
0.30	0.508	4.805	0.01	0.022974	77.077
			0.005	0.011545	152.790

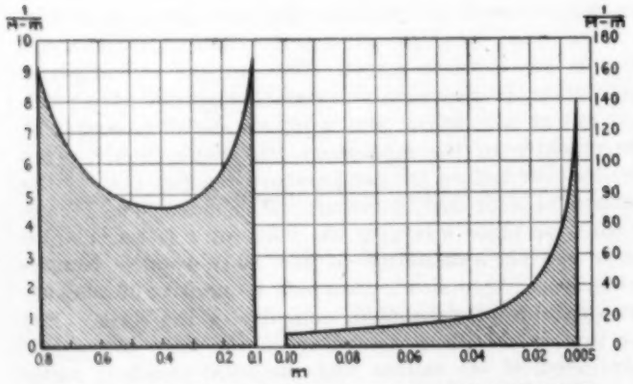


FIG. 1—DIAGRAM OF THE AREAS REPRESENTED BY $\int_{m_o}^{m} \frac{dm}{M-m}$

The area between the curve, the x-axis, the extreme values of m is $N = 6.52$, which gives

$$k = 1 + \frac{1}{6.52} \log_e \frac{0.8}{0.005} = 1.778$$

This represents, therefore, the relation between the composition of vapor and liquor for benzene distilled out of mixtures of benzene and toluene during the distillation of which the concentration of benzene in the liquor passes from 80 per cent to 0.5 per cent.

It is interesting to verify the correctness of the calculated results as compared with those obtained experimentally. During the war, considerable attention was paid to mixtures of benzene and toluene. In an article[3] which appeared in 1916 in the *Journal of the Society of Chemical Industry* are given the boiling points of such mixtures containing the proportion of benzene indicated in the second column of following table. The third column gives the composition calculated according to the method previously discussed:

Temperature, Deg. C.	Percentage of Benzene in Mixture. Observed	Calculated
81.8	90	90.98
83.7	80	80.96
85.75	70	71.17
88.1	60	61.06
90.75	50	50.74
93.8	40	40.30
97.2	30	30.07
101.0	20	20.04
105.3	10	10.08

As will be observed, the differences are small enough to be neglected in ordinary distillation practice. The laws we have utilized to arrive at this result can also be applied to the distillation of other mixtures of the aromatic hydrocarbons as well as those of the paraffin series. It will be noted that the method is to be applied to a chosen component, independently of, and disregarding other components in the mixture.

Ceramic Imports and Exports of Belgium

Commerce Reports for Jan. 16, 1922, summarizes the foreign trade of Belgium in ceramics.

Reviving trade with Germany was one of the outstanding features of Belgium's 1921 imports of ceramic products. Of the ten classes of pottery imports shown in Belgian official statistics, Germany was the chief source for six, France for three and the Netherlands for one. In glassware out of twelve items Germany led in ten and France in two.

Belgium is, however, a much larger exporter than importer of ceramics, its sheet and plate glass having a world-wide reputation for quality and even its more bulky pottery products finding markets in South America and other distant fields. The latest available figures relating to Belgium's foreign trade in ceramic products are those covering the first nine months of 1921. These, with corresponding 1920 data for comparison, are summarized below:

Pottery	Imports Jan.-Sept., 1920, Kilos	Imports Jan.-Sept., 1921, Kilos	Exports and Re-exports. Jan.-Sept., 1920, Kilos	Exports and Re-exports. Jan.-Sept., 1921, Kilos
Earthenware, fine (except tiles)	2,592,890	3,405,721	1,735,355	1,668,371
Chinaware (except tiles)	668,743	1,065,216	77,798	171,818
Terra cotta:				
Bricks, drainage pipes, etc.	41,806,517	75,171,989	342,779,715	598,509,249
Tiles—				
Varnished or enameled, and tongued-and-grooved	2,178,970	4,582,965	21,464,157	28,702,901
Other	2,000,537	531,115	16,310,140	19,232,390
Paving and building blocks and tiles:				
Of earthen or stoneware	443,343	272,783	16,400,408	11,108,272
Of concrete	225,307	75,396	14,399,797	11,921,717
Of fine earthenware or china	132,385	184,940	4,490,460	3,241,376
Not specified	166,121	451,350	5,936,398	1,626,787
Common pottery	1,758,432	1,892,900	4,481,400	1,876,553
Total quantity	51,973,245	87,634,375	428,075,628	678,059,464
	Francs.	*Francs.*	*Francs.*	*Francs.*
Total value	24,619,360	27,947,507	53,011,314	63,523,762

[3] *J. Soc. Chem. Ind.*, 1916, vol. 10, p. 586, "The Estimation of Benzene and Toluene in Commercial Mixtures."

Production of Shrunk Coke in Electrode Manufacture

BY J. L. MCK. YARDLEY
General Engineer, Westinghouse Electric & Manufacturing Co.

CARBON and graphitized electrodes are made from retort carbon, petroleum coke or anthracite coal. Petroleum coke is probably the most desirable material for this purpose, since it consists of from 90 to 95 per cent of fixed carbon of from only 5 to 10 per cent of volatile matter, and has less than 1 per cent of either sulphur or ash. In addition, it is easily obtainable in quantity. It has been quoted recently at $12 to $13 per net ton at the refinery Atlantic seaboard. It is the final product in the dry or cracking distillation of paraffine base petroleum and is obtained by the destructive distillation of the tar. The yield is about 10 per cent of the tar or 1 per cent of the petroleum dry distilled. It is particularly desirable to have this material as the principal constituent of electrodes which are to be used in furnaces or in electrolytic processes, into which the least possible amount of silicon impurity should be introduced.

The manufacture of electrodes must meet most exacting requirements from the various industries in which they are employed, and success is dependent upon attention to particulars in the various departments, such as

1. Selection of materials.
2. Calcination of materials.
3. Grading and mixing of materials.
4. Extrusion of homogeneous green electrodes under pressures up to 600 tons.
5. Gradual and uniform baking to an ultimate temperature in the neighborhood of 1,400 deg. C.
6. (Where desired) Graphitizing of baked electrodes in an electric furnace at a temperature above 2,000 deg. C.

These steps in the process of manufacture are all important and interesting, particularly the baking of the electrodes. This is carried out in a large number of producer gas-fired furnaces or pits of ingenious construction and arranged so as to give a high thermal efficiency. In recent installations the calcining of materials is carried on in the electric furnace. Since the raw materials contain considerable volatile constituents, these must be driven off in the calcining operation to form what is called shrunk coke.

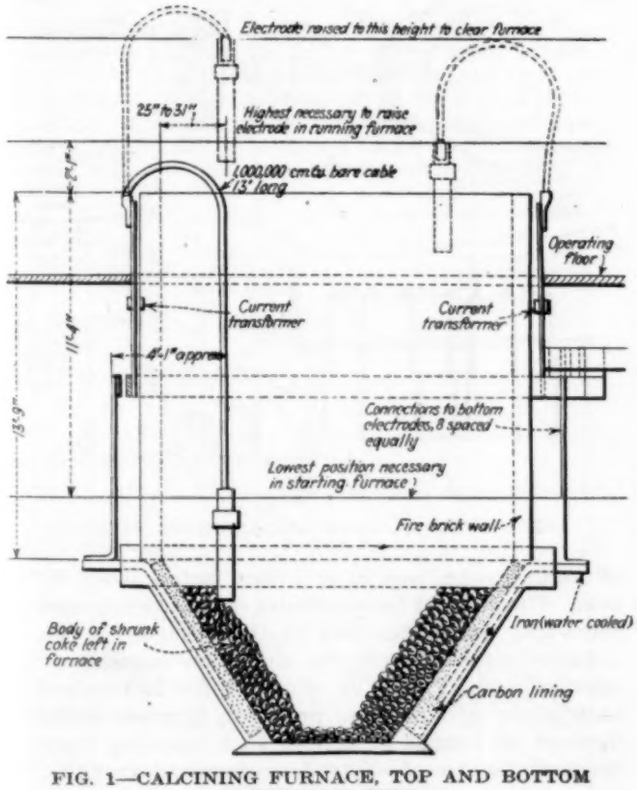

Electrode raised to this height to clear furnace
25" to 31"
Highest necessary to raise electrode in running furnace
1,000,000 cm. cu. bare cable 13' long
Operating floor
Current transformer
Current transformer
4'-1" approx.
Connections to bottom electrodes, 8 spaced equally
Lowest position necessary in starting furnace
Fire brick wall
Body of shrunk coke left in furnace
Iron (water cooled)
Carbon lining

FIG. 1—CALCINING FURNACE, TOP AND BOTTOM ELECTRODE TYPE

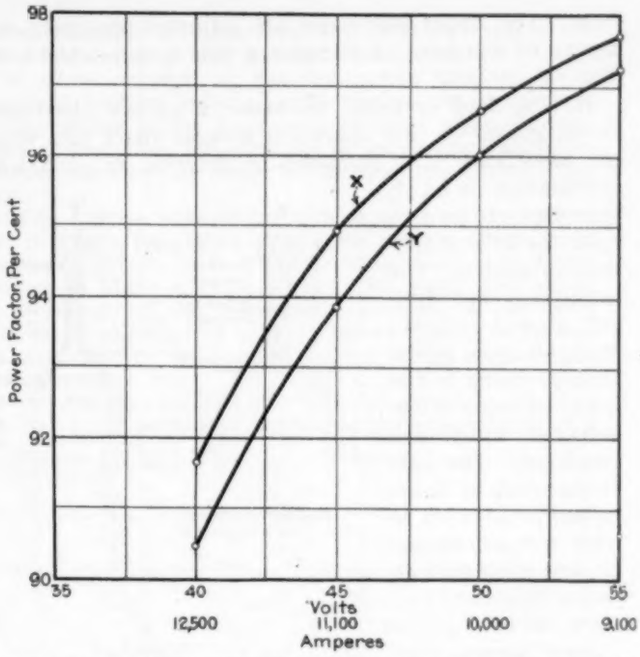


FIG. 2—POWER FACTOR OF 500 KVA. CALCINING FURNACE. SINGLE PHASE, 25 CYCLE

Calcining is performed in an open top, single-phase electric furnace of either the two-top electrode type or the top and bottom electrode type. Usual capacity for the former is 500 kva., and around 1,000 kva. for the latter type. Power is applied approximately 24 hours, or until a certain kw.-hr. energy has been expended as pre-established for the material charged. The furnace is left idle to cool for the next day, and on the following day it is emptied and made ready for the next heat. Therefore three furnaces of the present type are required for a cycle for continuous operating, giving an output of about 25 tons a day.

The 1,000-kva. top and bottom electrode type furnace itself consists of a cylindrically shaped steel shell, about 13 ft. in diameter and 14 ft. high. A brass strip is inserted to prevent a complete magnetic circuit. The cylindrical walls are lined with firebrick. The bottom, which may be flat or shaped like an inverted truncated cone, is also lined with firebrick, over which a high-grade dry carbon lining is placed and over this is placed a thin layer of sheet metal to prevent the tar from the petroleum coke from soaking into the lining and ruining it. Eight iron bars are laid in the carbon lining projecting radially toward the center. The bars and the carbon lining constitute one set of electrodes, the current being carried from them by copper connectors to the busbars, which encircle and are supported by the steel shell. The other set of electrodes consists of eight carbons about 7 in. in diameter and 4 ft. long, which are cast about an iron bar approximately 1 x 6 in. in section and 4 ft. long. These bars are attached to flexible copper cables 13 ft.

long. The upper electrodes are adjusted manually by means of winches. A furnace of this type is shown in Fig. 1.

Having had occasion to make a rather thorough investigation of this operation several years ago with my associates, it is proposed to describe an electrical installation which was developed to meet the difficult conditions involved. The conditions are difficult, particularly with 60-cycle power supply, owing to the heavy currents at low voltages which are employed. The particular ends to be attained in addition to high over-all efficiency, are high over-all power factor and uniform division of current between electrodes where there are a number in parallel, so as to produce a uniform heating effect and also ease in operation, and between the parallel secondary supply circuits to the electrodes. As an example of the care with which such furnace installations should be designed, Figs. 2 and 3 are supplied, showing the results of an analysis of two proposed lead arrangements for a number of 500-kva., single-phase, two-top electrode type calcining furnaces. In this case, the rate at which power would be paid for, as well as the amount of power into the furnace, was dependent upon the power factor, and although the supply was at 25 cycles, extra precautions in design were deemed necessary. In Fig. 2, curve *X*, as compared with curve *Y*, shows the calculated improvement in power factor obtained by interlacing the copper bars for the 6-ft. run according to diagram *X*, Fig. 3, as compared to the non-interlaced arrangement shown in diagram *Y*, Fig. 3.

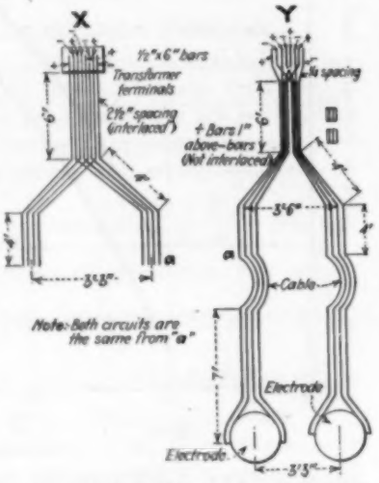


FIG. 3. METHODS OF CONNECTING LEADS
X = 6-ft. run leads interlaced.
Y = 6-ft. run leads non-interlaced

Referring to the installation layout shown in Fig. 4 in order to have an output of 50 or 60 tons per day, it was proposed to operate a total of six furnaces similar to the one described. The furnaces would be arranged in two groups of three each. By converting from the three-phase transmission voltage to two-phase furnace voltage, the two furnaces taking power each day would form a practically balanced load upon the power system. Power would be cut off from the other furnaces by lifting up and disconnecting their movable electrodes. Each furnace taking power would receive its current through eight movable electrodes and eight corresponding fixed electrodes. There would be eight separate circuits back to the transformer, each capable of being independently adjusted to give the desired amount of current and each tending, on account of its own impedance, more readily to give that current. The principal equipment proposed for this installation includes:

Two 1,250-kva., single-phase, 60-cycle, maximum rated stepdown transformers, Scott connected for three-phase, 13,200 volt high tension, two-phase 2,200 volt low tension and provided with full capacity taps to give 2,310. 2,420, 2,530 and 2,640 volts low tension. Two 1,200-kva., single-phase, 60-cycle, maximum rated furnace transformers, with 2,640 volt high-tension and low-tension voltages 48, 54, 60, 66, 72 and 84 at full capacity, and 42 at reduced capacity. When operated at 2,200 volts high tension, these transformers designed to give low-tension voltages from 35 to 70 in 5-volt steps.

The operation of the furnace is as follows:

One electrode is lowered to the bottom of the furnace and an arc is set up. The petroleum coke is placed around that arc until current will flow through it. Then an arc is started at a second electrode in similar manner, and this process is continued until all electrodes are in operation. The furnace is then loaded and the electrodes are raised as rapidly as possible, while still maintaining a condition of having considerable current flowing through them. Finally the furnace is practically full and the electrodes are in their upper position imbedded in the coke. Except at starting, the heating of the mass is entirely through the resistance of the material itself.

The average total power consumption of this plant would be in the neighborhood of 900 kw.-hr. per ton

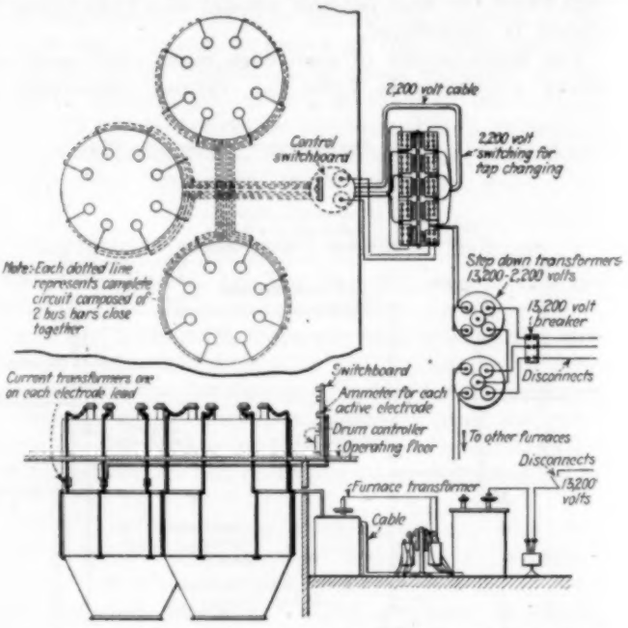


FIG. 4—INSTALLATION OF CALCINING FURNACE

of shrunk coke, and at a power factor above 90 per cent. The demand for electrodes in the electric steel and ferro-alloy industries and in the electrolytic chlorine industry, as well as in the aluminum industry, where approximately ⅔ to ¾ lb. of electrodes is required for each pound of aluminum produced, is great enough to demand the output of several such calcining plants in the manufacture of electrode carbon and graphite.

Panama Canal to Sell Surplus Supplies

The Panama Canal is about to offer for sale a large quantity of surplus material now in stock on the Isthmus, including manila rope, copper screening, nails, glass, paints, lubricating oils and greases, millwork, chemical materials, hose, chain, pig iron, non-ferrous metals, burlap, canvas, foundry supplies and numerous other commodities.

Interested parties should communicate with the General Purchasing Officer, the Panama Canal, Washington, D. C., for detailed information as to the material available for sale, terms of sale, etc.

Synopsis of Recent Chemical & Metallurgical Literature

Bond Clay Mixtures for Glass Pots.—D. H. Fuller, of the U. S. Bureau of Standards, has made some studies to determine whether as good results can be obtained from mixtures of American clays as from the Gross Almerode clay in glass pot bodies and reported in the *Journal* of the American Ceramic Society for November. Two American ball clays were combined in various proportions with two siliceous American bond clays and compared with the Gloss Almerode clay in bodies containing 50 per cent grog. Physical properties and resistance to glass batch corrosion were determined. It was not found possible to duplicate the physical properties, especially the low water of plasticity and low drying shrinkage of the Gross Almerode body, but several of the bodies gave better results as regards resistance to corrosion than the one containing the Gross Almerode clay. In general it was concluded that it is possible by blending American clays to produce a body equal or superior to the Gross Almerode body. More thorough heat-treatment of pots or tank blocks in the arches and greater uniformity in temperature during the burning is required.

On the Distribution of Temperature in Steel Ingots During Cooling.—Seizô Saitô, the author of this paper appearing in the 52nd report from the Japanese Iron and Steel Research Institute (*Science Reports*, vol. 10, No. 4, Sept. 1921), aware of the complexity of the mathematics that accompanies the consideration of octagonal and hexagonal shapes, deals only with cylindrical and square molds. The heat of solidification is also omitted, hence the calculations apply to cooling below the solidification point. The initial temperature of the melt is supposed to be 1,600 deg. C., and that of the mold is 0 deg. C., and it is assumed that there is no convection of heat and that the constants have the same value both in the liquid and solid states. The complex derivations of the mathematical formulas cannot be abstracted, but the plotted diagrams obtained from the numerical values are reproduced as far as they are of interest.

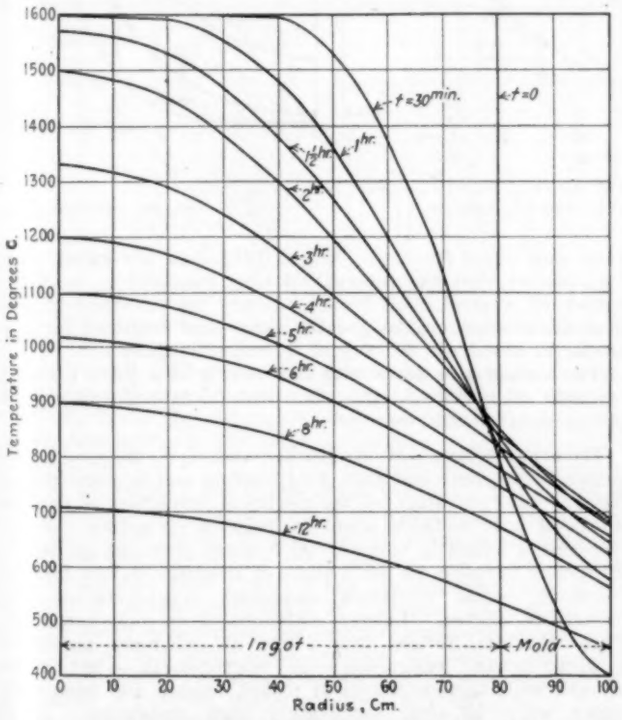


FIG. 1—TEMPERATURE-DEPTH CURVES AT VARIOUS TIME INTERVALS AFTER POURING

The numerical data on heat conduction obtained for a cylindrical ingot of infinite length disclose the distribution of temperature in the ingot and the mold after different lapses of time; also the variation of temperature at different distances from the center for definite time intervals are given.

In Fig. 1 there is shown the manner in which the isothermals fall from the center toward the surface of the mold in an ingot 160 cm. (5 ft. 3 in.) in diameter—that is, corresponding to about a 60-ton ingot. This graph also shows the magnitude of the temperature gradient in the inner portions, which coincides with the known rules of solidification and which is visible in an etching of the cross-section as a segregation ring.

Fig. 2 discloses the fact that with the exception of points near the inner surface of the molds the temperature at a given point falls continuously as time goes on, but that at points near the mold the temperature falls rapidly at first and then increases as the time elapses, after which a gradual cooling proceeds in the usual way. The temperature of the mold increases rapidly at first and after reaching a maximum gradually decreases with time. In other words, the mold and the ingot equalize and after equalizing both appear to cool as a unit. In fact, this is only a mathematical result which supports the actual facts of everyday practice. Since in practice the weight of a mold is equal to the weight of the ingot, the temperature reached by the mold will be approximately half the temperature of the ingot.

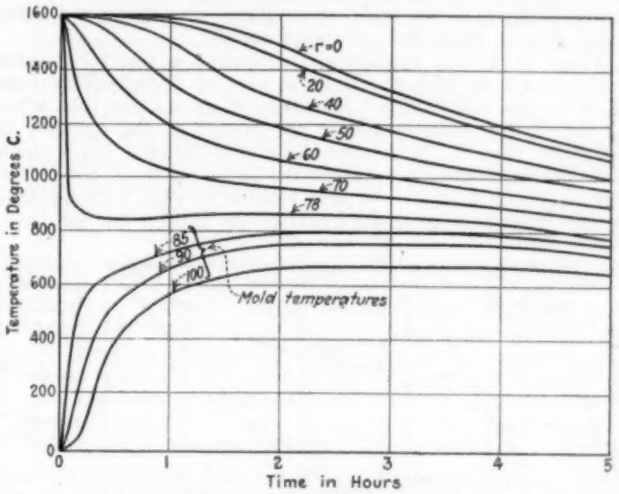


FIG. 2—TEMPERATURE-TIME CURVES FOR VARIOUS POSITIONS IN INGOT AND MOLD

Fig. 3 represents an actual experiment with a melt that has been cast in a mold of an outer radius of 40 cm. and inner radus of 27 cm. of 180 cm. mold length, the tempera-

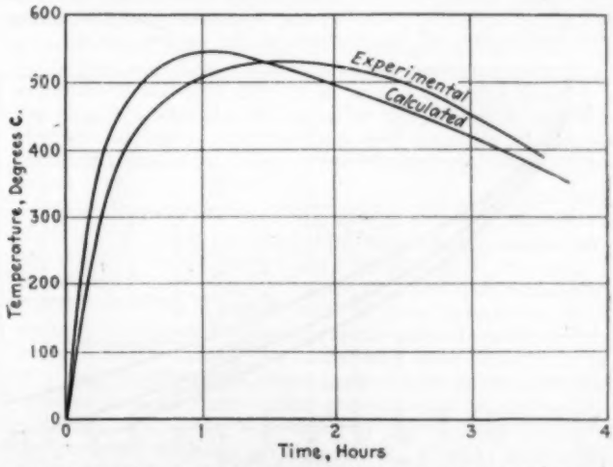
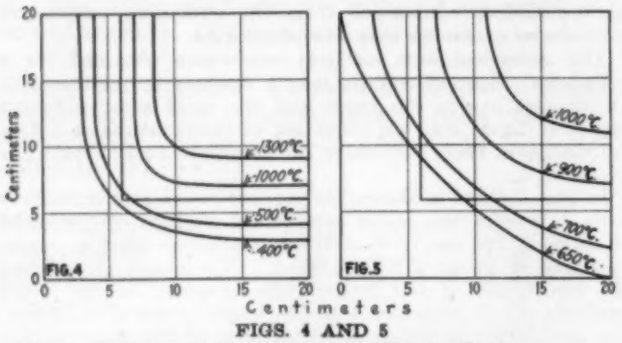


FIG. 3—COMPARISON OF CALCULATED AND OBSERVED TEMPERATURES OF OUTSIDE OF INGOT MOLD



FIGS. 4 AND 5

Fig. 4—Isothermals in square ingot after 1 minute.
Fig. 5—Isothermals in square ingot after 5 minutes.

ture of the melt being 1,500 deg. C. The temperature of the outer surface of the mold at midheight as measured coincides closely with the calculated result.

There is also a numerical calculation given for a case which assumes that the mold is kept at 0 deg. This case is of no practical value. However, it points out that after 12 hours the temperature at the center of the cylinder is only 200 deg. C., a temperature considerably lower than that in the former case after the same lapse of time (710 deg. C., from Fig. 1). A plot similar to Fig. 2 shows that in the inner portion of the cylinder the rate of the temperature fall with increasing radius is very small and its gradient almost the same as with an uncooled mold. Hence we may conclude that in the case of such a large ingot, although the outer surface of the mold is rapidly cooled by some special means, segregation cannot be prevented, and the diameter of the segregation ring also remains almost unaffected.

An infinitely long prism with a section 68 cm. square (2 ft. 3 in.) was calculated. Figs. 4 and 5 show the calculated and plotted curves, with the characteristic that the isothermal lines round off the corners of the square.

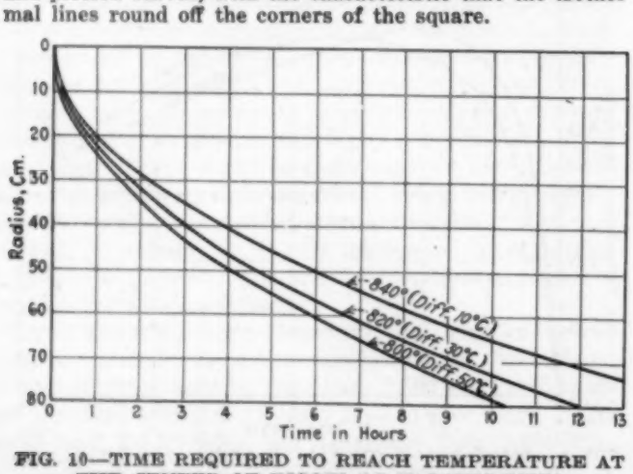


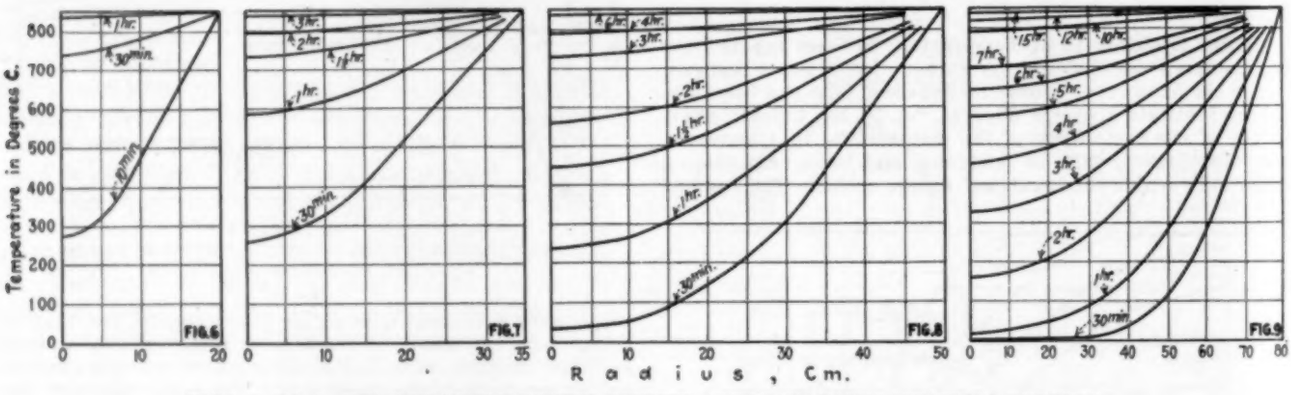
FIG. 10—TIME REQUIRED TO REACH TEMPERATURE AT THE CENTER OF INGOTS OF VARIOUS SIZES

Thermal stress in a steel ingot in which the temperature distribution is not uniform has already been solved by Lorenz, in his "Technische Elastizitäts Lehre," and Saitô's calculations follow his method.

A problem of practical importance dealt with is that of annealing large ingots or thick plates. A mathematical solution of this is already well known, but the author states that the data at hand are not trustworthy.

It is assumed that the cylinder in the mathematical problem is initially at 0 deg. C., and its surface is always kept at 850 deg. C. The calculations show the distribution of temperature at different time intervals for the radii 20 cm., 35 cm., 50 cm. and 80 cm., and the results are given in Figs. 6, 7, 8 and 9. Calculated results are also given for the temperature at axis of each cylinder corresponding to different time intervals. The time required for obtaining 800 deg. C., 820 deg. C. and 840 deg. C. at the axes of various cylinders are shown in Fig. 10, assuming a constant skin temperature of 850 deg. C. The curves resemble parabolas.

When computing data on the cooling of heated cylinders or plates, the surrounding temperature is assumed to be kept at zero and the temperature distribution is just the reverse of the above. In practice, however, the boundary conditions are not the same as those required in the assumed theory. In actual heating the outer surface will acquire the heat by radiation and hence it will require a much longer time than that expected from the theory. Verification of this fact is given by E. F. Law, *Journal*



FIGS. 6 TO 9—TEMPERATURE-DEPTH CURVES AFTER VARIOUS HEATING PERIODS

Fig. 6—40-cm. cylinder. Fig. 7—70-cm. cylinder. Fig. 8—100-cm. cylinder. Fig. 9—160-cm. cylinder.

Iron and Steel Institute, No. 1, 1918. In his experiment Law shows that the interval of time required to heat the center of a steel cube from ordinary temperature to 900 deg. C. is considerably greater than that required for the center to cool from 900 deg. C. to room temperature.

The author also deals with the cooling of a thick plate or cylinder of infinite length, the heat of transformation of which is taken into account.

Titanium Alloys.—M. A. Hunter and J. W. Bacon (Rensselaer Polytechnic Institute, Engineering and Science Series, No. 12) have investigated the electrical properties of various alloys of pure metallic titanium, reduced by sodium. If 0.5 per cent is added to commercial Norway iron and melted in an Arsem furnace, all but a trace of titanium is lost, but the resulting metal exhibited improved magnetization and hysteresis curves. Larger additions were not beneficial. Pure titanium, forged into a rod at red heat, possesses a high specific resistance — 88 microhm-cm. — but when alloyed with various alloys of nickel, copper and iron, produced wires of only moderately high resistance. It is exceedingly hard to draw such alloys containing more than 5 per cent titanium.

Terra Cotta Casting.—Technology in the manufacture of terra cotta has become an accomplished fact. R. F. Geller of the U. S. Bureau of Standards published a paper in the November issue of the *Journal* of the American Ceramic Society on possibilities of terra cotta casting. The experimental methods described therein involved the treatment of clays and bodies with varying amounts of salts and cast in the form of small ashlars. The casting properties, vis-

cosity, specific gravity and drying behavior of three kaolins, two ball clays, one fireclay and four representative commercial bodies, together with terra cotta clays, were studied. The author concluded that kaolins have an open structure, but do not develop strength on drying. Bonding properties are furnished by ball clays, which, however, tend to seal against the mold. Commercial terra cotta bodies tested do not possess good casting properties, but can be modified through a study of the component clays. Mechanical difficulties attending the casting of terra cotta render the feasibility of the process doubtful at the present time.

Recent Chemical & Metallurgical Patents

British Patents

For complete specifications of any British patent apply to the Superintendent, British Patent Office, Southampton Buildings, Chancery Lane, London, England.

Crystallizing.—Granular crystals—for example, of sodium chloride—are obtained from solutions by supersaturating a solution out of contact with crystals by evaporation or by cooling, and circulating the supersaturated solution through a mass of crystals which are caused to grow. The agitation of the mass of crystals may cause the formation of spherical granules. The solution drawn from an evaporating chamber *b*, Fig. 1, is forced by a pump *g* through a superheater *a* and pipe *i* back to the evaporating chamber. Evaporation takes place at the upper surface *o* and the supersaturated solution is drawn upwards through an inner chamber *e* containing a mass of crystals. When the crystals have attained a certain size they fall against the flow

FIG. 1.

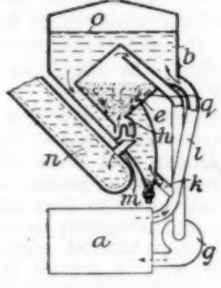
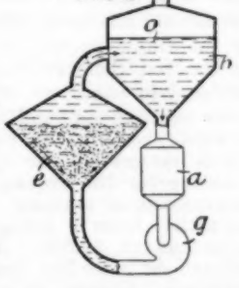


FIG. 2.



of the liquid into the base of the vessel *e* and are discharged through an opening *h* and through a pipe *m* to an elevator *n*. Curved baffles *q* inside the vessel *e* cause all parts of the crystal mass to pass over the opening *h*. When the solubility of the substance does not increase rapidly with the temperature, the solution may be passed through the superheater *a*, Fig. 2, directly into the crystallizing vessel *e* and thence into the evaporating vessel *b*. To prevent fine crystals being carried from the crystallizing vessel, fresh solution may be fed by a jet discharging into an open coiled pipe or chamber in the upper part of the vessel *e*. Alternatively, the small crystals may be removed from the circulating current of solution by filtration, centrifugal treatment or by settling, or the discharge opening *h* may be arranged so that some small crystals are discharged with the large crystals. The separation by settling may be effected by leading a part of the circulating flow through a pipe *k*, Fig. 1, into the lower part of the vessel *b* in which settling occurs and from which the liquid passes again into the main circulation. Supersaturation of the solution may be effected by cooling the solution at the surface *o* of the vessel *b*, the superheater *a* being dispensed with. The evaporation or cooling may be accelerated by blowing air through the solution. (Br. Pat. 171,370. Not yet accepted. Aktieselskabet de Norske Saltverker, Bergen. Dec. 31, 1921.)

Chromic Sulphate.—Chromate or bichromate of sodium or potassium is treated with sulphuric or other acid to give a solution of chromic acid. The latter is freed from the alkali salt present by cooling to 0 deg. F. and separating the resulting crystals, preferably by centrifugal action. The chromic acid, on saturating with sulphur dioxide, gives a chromic sulphate solution. The alkali salt may be removed from the extractor by dissolving the crystals in water. (Br. Pat. 171,149. F. M. Mooney, Montreal. Dec. 30, 1921.)

Tanning Materials.—Waste sulphite-cellulose lye is treated with lime or calcium carbonate to neutralize the acids, and is separated from the precipitate. The calcium is then precipitated by alkali compounds such as sodium carbonate or silicate. Hydrochloric, sulphuric or other acid is added to the resulting solution of sulpho-lignates in amount equivalent to 50 to 100 per cent of the alkali used in precipitation. The liquid can then be used for tanning. Instead of acid, there may be added salts of metals such as are used in mineral tanning—for instance, aluminum, iron, or chromium chloride; the liquids thus obtained can be used directly for tanning. The liquid may be fermented after the addition of the lime or calcium carbonate, and may be concentrated by evaporation after the treatment with the alkali compound. (Br. Pat. 171,136. A. Romer, Stuttgart, and Deutsch-Koloniale Gerb. & Farbstoff Ges., Karlsruhe. Dec. 31, 1921.)

Heat- and Sound-Insulating Material.—A heat- and sound-insulating composition comprises slag wool or other fibrous material such as asbestos, hair felt, fossil earth and aqueous solution of casein, a sodium compound such as borax, soda ash or caustic soda and tung oil, or coal tar, pitch or asphaltum. Preferred proportions are slag wool 100 parts, casein 10 to 15 parts in 100 parts of water, tung oil 10 to 15 parts, borax 3 parts. The fibers are placed in a container, the other ingredients are boiled together and added, the manhole cover is screwed down, and compressed air or steam is admitted to mixing jets. The mixture is then forced into a porous or perforated mold. The composition may be applied directly to steam pipes, etc. (Br. Pat. 171,550. H. Smith and J. Fullock, London. Dec. 31, 1921.)

Purifying Cellulose Solutions.—Cellulose solutions such as are used for spinning artificial threads are freed from foreign or undissolved particles by subjecting the solutions to powerful centrifugal force. The separation may be effected in a rapidly rotating hollow cylinder, bottle shaped at the upper part and suspended vertically in ball bearings; the solution is introduced through an opening in the base of the cylinder, overflows at the neck and is collected in a surrounding rim, while the particles thrown out by centrifugal force collect as a compact layer along the walls of the cylinder, and are from time to time removed. For effective separation, the value of the centrifugal force must be higher than that ordinarily employed; thus with a cylinder having an internal diameter of 10 cm., the speed of revolution must be 15,000 r.p.m. or higher. (Br. Pat. 171,384. Not yet accepted. K. Fürst, Berlin. Dec. 31, 1921.)

Heat-Insulating Coverings.—Relates to heat-insulating coverings for the pipes of refrigerating machines and the like of the kind comprising a tubular sheath of fibrous material filled with granulated cork or similar material and adapted to be wrapped as a rope in one or more layers around the pipe. According to the invention, a sheath is made in a braiding machine and the granulated material is simultaneously delivered from a shoot, being guided into the sheath by means of a ring of warp threads which pass through the chute into the rope and form an integral part of the finished rope. (Br. Pat. 171,428. A. Nadin, Lancashire. Dec. 31, 1921.)

Glass Manufacture.—Black glass, which is of use as an electric insulating material, and which has a small thermal expansion, is made by melting a natural rock, such as schist, consisting chiefly of quartz, lime and alumina, and adding a further quantity of one or more of these substances until the melted product contains approximately 1 part aluminum oxide, 1.65 parts calcium oxide, and more than 3.56 parts of silica, the excess of silica beyond 3.56 parts being calculated so that all other oxides present may be converted into silicates. The main ingredient of the finished product has the chemical formula $(SiO_2)_6$, Al_2O_3, $(CaO)_2$ and melts at about 1,250 deg. C. (Br. Pat. 171,692. Not yet accepted. P. T. Freuler, Schwanden, Switzerland. Jan. 11, 1922.)

Technical News of the Week

Current Events in the Chemical, Metallurgical and Allied Industrial Fields—Legislative Developments—Activities of Government Bureaus, Technical Societies and Trade Associations

Secretary Weeks Doubtful of Ford Offer at Initial Hearing Before House Committee

Doubt as to the ability of Henry Ford to reduce materially the cost of fertilizer by the operation of the Muscle Shoals nitrate plant was expressed by the Secretary of War at the initial hearing on the Ford offer before the Military Affairs Committee of the House of Representatives. If he were convinced that, by the acceptance of this offer, the price of fertilizer could be reduced materially to the farmer, Secretary Weeks said, he would vote for its acceptance if he were a member of Congress. In view of the doubt as to the ability of Mr. Ford to cheapen fertilizers, Secretary Weeks expressed the personal opinion that more advantageous schemes for the utilization of the power at Muscle Shoals could be worked out. He said that the part of the contract referring to the obligation to produce 110,000 tons of ammonium nitrate per annum is not in business-like form. He called attention, however, to the generally held belief that the fixation of nitrogen is in its infancy and that great development in this art may be expected in the next few years.

Thinks Ford Would Accept Modifications

The attitude of the committee is evidently one of establishing whether or not the Ford offer is a business-like proposition. In answer to questions, Secretary Weeks expressed the personal opinion that Mr. Ford would accept modifications which will make the offer a very much better one. In justifying his apparent delay in handling the Ford offer, Secretary Weeks pointed to the fact that the offer in its present form not only establishes additional safeguards for the public interest, but is tantamount to an increase of about $14,000,000. He revealed that Mr. Ford is contemplating the immediate investment of $10,000,000 to $12,000,000 of his own funds, in addition to the amounts which Congress would be called upon to expend on dam construction.

Does Not Favor Government Operation

The Secretary emphasized his opposition to any attempt to embark the government in the manufacture of fertilizer. If the Ford offer is not accepted, he favors the completion of the dam by the government, but he made it very clear that the government's activity should not be extended to include the operation of the nitrate plant.

Few new points were brought out during the Secretary's testimony. He amplified the explanation contained in his letter transmitting the Ford offer and gave new emphasis to many points. Among those was his insistence that the lease should be for no longer period than 50 years. He also suggested that any sale of power by Mr. Ford, in case he did not use the entire output for his own industries, should be under regulations to be formulated by the Federal Power Commission.

That difficulties may be expected in adjusting claims with the Alabama Power Co. and that a substantial sum will be required to purchase the right of way for the 88-mile transmission line to the Warrior River plant, were predicted by Secretary Weeks.

Urges Guarantee of Continuous Operation

He urged that responsibility should be definite with regard to the manufacture of nitrate. There is difference of opinion as to whether or not the agreement would compel the operation of the nitrate plant at a loss. The Secretary suggested that there should be a guarantee, either by the formation of a company with sufficient capital or by the giving of a bond in sufficient amount, to insure the continuance of this operation throughout the life of the contract.

While several members of the committee very obviously have preconceived ideas as to just what ought to be done with the Ford offer, most of them appear to be open to conviction.

Bill for Reclassification of Technical Employees in Federal Service Reported to Senate

The bill reclassifying employees in the federal service, which was passed recently by the House of Representatives, has been reported to the Senate by its Committee on Civil Service with important amendments. The Senate committee has substituted the Civil Service Commission for the Bureau of the Budget as the classifying agency and has increased the salary range for professional and scientific services. In addition, the professional groups have been expanded so as to include editors, illustrators, transportation experts and nurses. The Senate bill also extended the classification to the field services. The House bill limited the compensation schedules to civilian employees in the District of Columbia.

Provides for Efficiency Records

The bill permits the transfer of employees between departments at a higher rate of payment. It establishes an efficiency rating system, and provides that the efficiency records are to be accessible to employees. The bill establishes a minimum efficiency standard which must be maintained or the employee will be dropped from the list. In reporting the bill Senator Sterling, the chairman of the committee, said in part:

> For the professional and scientific service the committee would restore the rates recommended by the reclassification commission. Under that scale the entrance salary for the lowest positions requiring scientific or professional training equivalent to that reached by graduation from a college or university would be $1,800 instead of $1,620. To the highest successful professional or scientific man who is placed in full administrative charge of a major professional or scientific bureau, it would pay from $6,000 to $7,200 unless a higher salary is specifically authorized by law. The House bill would give such an employee $5,400 to $6,600 unless a higher salary is specifically authorized by law. Such a change would add less than 2 per cent to the cost of reclassification.
>
> The government probably never can compete on the basis of salary with private business and industrial enterprises seeking to secure scientific and professional services. Those salaries, however, should bear a fairly close relationship to those being paid by the largest and strongest colleges and universities of the country.

Since the measure affects the budget, the bill does not go directly to the Senate calendar, but was referred to the Committee on Appropriations. There is a possibility that the Appropriations Committee will insist that it take its turn and follow the regular appropriation bills, which would mean a delay of many weeks.

New Chemical Laboratory Planned for University of West Virginia

The University of West Virginia, Morgantown, is having plans prepared for the erection of a new chemical laboratory at the institution, estimated to cost about $400,000. It is expected to call for bids late in February or early in March. Paul A. Davis, 1713 Sansom St., Philadelphia, Pa., is architect.

Dr. Richards' Metallurgical Library Given to Lehigh

In accordance with the will of the late Joseph W. Richards, his entire personal technical library of over 5,000 volumes has been donated to the department of metallurgy of Lehigh University. Dr. Richards, who was head of the department at the university until his death, felt the need of a complete library of metallurgical volumes separate from the university library. The removal of the standard works on metallurgy from the university library to supplement the Richards collection is being considered and would give the university one of the most complete metallurgical libraries in the country.

Industrial Developments of the Week

Glass. The Indiana Window Glass Co., Vincennes, Ind., has resumed operations at its plant, following a considerable period of curtailment. Employment will be given to more than 300 men.

The Hawley Glass Co., Hawley, Pa., manufacturer of bottles and other hollowware products, has reopened its plant after a shutdown of about 7 months. Orders are said to have been received to insure continuous operation well into next fall.

The Tampa Glass & Bottle Manufacturing Co., Tampa, Fla., recently organized to succeed the Southern Bottle Manufacturing Co., is arranging for the resumption of operations at the local plant before the close of the month.

The different window glass plants in the Clarksburg, W. Va. district are resuming operations, and since the first of the month about 2,500 workers have returned to the factories.

Paper. The Warren Manufacturing Co., Milford, N. J., has recently added about fifty men to its working force and is operating at full capacity. The company manufactures glassine and other papers.

J. G. Wieder, Macungie, Pa., operating a paper box-manufacturing plant, has adopted a night working schedule for increased production.

Rubber. The Fiske Tire Co., Chicopee Falls, Mass., has increased production at its local plant to about 9,000 tires a day, as compared with 3,000 per day during the low point of manufacture last spring. It is planned to advance the output gradually during March, April and May until capacity of about 15,000 casings per day is reached. The Cudahy, Wis., branch of the company is maintaining an output of about 3,000 tires a day.

The Du Bois Tire & Rubber Co., Chattanooga, Tenn., has commenced operations at its new local plant, recently completed, and is said to have taken orders to insure capacity output for the entire year.

The B. F. Goodrich Co., Akron, Ohio, has adopted a production schedule of from 17,000 to 18,000 casings a day at its local works.

Cement. Practically all of the cement companies in the Nazareth, Pa., district have adopted a night shift at their mills for increased production, including the Nazareth Cement Co., Phœnix Portland Cement Co., Hercules Cement Corporation and the Dexter Portland Cement Co. The mills are giving employment to more than 3,000 workers.

Iron and Steel. The Scranton Iron & Steel Co., Scranton, Pa., has resumed production at close to normal in all departments of the plant for the first time in several months.

The Cumberland Steel Co., Cumberland, Md., has recently resumed production at its plant following a short shutdown.

For the first time in many months the Allegheny Steel Co., Brackenridge, Pa., is operating at practically 100 per cent in all departments of the works.

The Inland Steel Co., Chicago, Ill., is increasing production at its mills to close to 75 per cent capacity.

The Cambria Steel Co., Johnstown, Pa., has placed three more open-hearth furnaces at its Franklin Works in operation, making a total of fifteen furnaces in service. The No. 3 mill at the lower plant has also been reopened.

Coke. After more than a year of idleness, the H. C. Frick Coke Co. has resumed partial operations at its Colonial No. 3 and Hecla No. 1 plants in the Uniontown, Pa., section.

Miscellaneous. The Nickel Alloy Co., Hyde City, near Clearfield, Pa., has resumed operations, following a shutdown for about 13 months past. The production will be devoted exclusively to nickel alloys and steel manufacture will be entirely discontinued.

The J. B. Ford Co., Detroit, Mich., manufacturer of soda ash, etc., is increasing production at its plant, and during the first 3 weeks of January the output was larger than for any month during the past year.

Procter & Gamble, Kansas City, Mo., manufacturers of soaps, etc., are operating their local plant at close to normal, with regular force of employees.

The Mathieson Alkali Works, Niagara Falls, N. Y., have increased production at their local plant to about 80 per cent of capacity.

Fire destroyed the main building of the American Aniline Products, Inc., plant at Lock Haven, Pa., on Feb. 1. The fire originated in one of the color grinding mills and destroyed considerable quantities of raw materials and finished dyes, the loss being estimated at $200,000.

Voluntary Refund of Excess War Profits by Eastman Kodak Co.

The Eastman Kodak Co. has presented to the government a check for $182,770.60, representing the profit of the company on apparatus and materials for the Aircraft Service of the War Department in excess of 10 per cent. In the letter accompanying this purely voluntary refund George Eastman explained that in accepting the contracts from the government during the war, the company had no definite figures upon which to base costs and it was necessary to make a liberal estimate in order to protect the company against loss. As soon as the complete final cost figures could be compiled, the profit in excess of the agreed 10 per cent, represented by the present payment, was made.

Acknowledgment was made by General Pershing as acting Secretary of War in the following letter:

> My dear Mr. Eastman: In receiving your check for $182,770.60, representing the monetary refund to the government by the Eastman Kodak Co. of its profits on War Department war contracts in excess of 10 per cent, I wish to express to you my high appreciation of this fine and patriotic action on the part of your company. Such a wholesome and generous attitude might well be expected during war times, but with the lapse of 3 years since the armistice, it is truly refreshing and inspiring to find such motives and high ideals animating a large business organization in its relation with the government.
>
> JOHN J. PERSHING,
> Acting Secretary of War.

Start of Dye Investigation Still Indefinite

An organization meeting of the sub-committee of the Senate Committee on the Judiciary which will conduct the dye investigation was held Feb. 7. Senator Shortridge was designated as chairman of the sub-committee. The date for the first open hearing will not be fixed until Senator Reed can be present.

The attitude of the American Dyes Institute with respect to the inquiry was made known in a letter by R. C. Jeffcott, addressed to Senator Shortridge.

"The American Dyes Institute and its members wish to let you know that they want to co-operate with you and facilitate your labors in every way," the letter states. "The resolution is comprehensive, and those engaged in the dye industry of the country welcome a most thorough and impartial examination of all questions covered by it."

Patent Bill Near Final Stage

Approval of the plan for the early consideration of the Patent Office relief bill has been secured from Senate leaders. It is expected that the bill will be called up in the very near future and passed with a minimum of discussion.

Soap, Oil and Alkali Manufacturers Ask for Lower Freight Rates

Petitions were presented to the Interstate Commerce Commission Feb. 8, asking for a reduction in the freight rates on cottonseed oil, soaps and soda ash, bicarbonate of soda and caustic soda. The petitioners represented the Southern Cotton Oil Co., the American Cotton Oil Co., all of the manufacturers of nationally advertised and distributed soaps and the members of the Alkali Manufacturers' Association.

It was testified that in general wages and other operating costs have been reduced to about 140-150 per cent of pre-war, while the freight rates on these products remain at 180-220 per cent of the pre-war level.

S. J. Cassels, the district manager for the Southern Cotton Oil Co. at Montgomery, Ala., testified that in 1921 only 300 of the 750 cottonseed crushing mills were in operation throughout the entire season. Two hundred operated at part time but the remainder were closed down continuously. To some extent this was due to the shortage in the cotton crop, but the witness said that the high freight rates have been a contributing cause. They have had the effect of localizing the business of each mill so that it could draw its seed only from short distances and likewise limited it in distributing cattle feed, fertilizer and other bulky byproducts.

American Welding Society Issues First Copy of Its "Proceedings"

The American Welding Society has issued, under date of January, 1922, the first copy of its *Proceedings*, in the form of a well-printed 44-page pamphlet. About half the space is taken up with society activities, related news and a bibliography of welding literature. The remainder is filled with technical papers, discussing methods and principles of various phases of welding.

This society was organized in 1919, and an attempt was then made to issue a journal, but it proved too expensive. Then for more than a year the *Welding Engineer* gave part of its space for the society proceedings. Even with the best will in the world, such an arrangement could not prove altogether satisfactory to each party, and the present *Proceedings* is an attempt to improve the society's service to its members.

Navy Department Solicits Bids

The Bureau of Supplies and Accounts, Navy Department, Washington, D. C., will receive bids up to Feb. 28 for 15,000 lb. of lump rosin; 200 qt. of liquid bronze; 5,000 gal. of turpentine, and 3,000 lb. of artificial vermilion, for use at the Mare Island (Cal.) Navy Yard. (Schedule 9420.)

Personal

E. O. BENSON, JR., has left the Jackson Laboratory of E. I. du Pont de Nemours & Co., Wilmington, Del., to accept a position as research chemist with John Campbell Co., manufacturer of dyestuffs, Newark, N. J.

G. S. BROWN has been re-elected president of the Alpha Portland Cement Co., Easton, Pa.

Dr. HAROLD S. DAVIS has resigned from his industrial fellowship at the Mellon Institute of Industrial Research of the University of Pittsburgh to accept a position on the research staff of Arthur D. Little, Inc., Cambridge, Mass.

PHILIP DEWOLF has severed his connection with the Davison Chemical Co. and entered consulting work, with headquarters at Westport, Conn. He will specialize in the manufacture of sulphuric acid, problems of evaporation and the industrial applications of silica gel.

WILLIAM C. DUDLEY has been re-elected president and general manager of the Dudley Paper Co., Lansing, Mich.

ANDREW H. GREEN, JR., vice-president of the Solvay Process Co., Syracuse, N. Y., and connected with that organization for many years, has been elected president and general manager of the Charcoal Iron Co. of America, Detroit, Mich., succeeding Frank W. Blair, resigned.

J. S. NEGRU, Managing Editor of CHEMICAL & METALLURGICAL ENGINEERING, sailed Feb. 11 for a 6 months' trip through Germany, France, Belgium and other European countries. The purpose of the trip is to study industrial and economic conditions and observe the latest advances in science, engineering and technology.

Dr. ERNEST FOX NICHOLS, who recently resigned the presidency of the Massachusetts Institute of Technology, Cambridge, Mass., is to return to Cleveland to resume the directorship of pure science research in the Nela Research Laboratory of the General Electric Co.

Dr. WILLIAM H. NICHOLS, chairman of the board of trustees of the Brooklyn Polytechnic Institute for the past 17 years and a member of the board for 32 years, has resigned. He will, however, continue to serve the Institute as vice-chairman.

F. W. PICKHARD, one of the vice-presidents of E. I. du Pont de Nemours & Co., has been appointed general manager of the dyestuffs department, with W. F. HARRINGTON as assistant manager. C. A. MEADE, vice-president and former general manager of the dyestuffs department, and M. F. POUCHER, former director of sales, have been made executive staff officials.

JAMES H. RANSOM has changed his position as research chemist with the Michigan Smelting & Refining Co., Detroit, Mich., to head the department of chemistry in James Millikin University, Decatur, Ill.

J. W. SMITH and D. R. SHARPE, superintendent and manager, respectively, of the minerals department of the Louisiana State Conservation Commission, have resigned.

ROBERT STEINEMANN has been elected vice-president and general manager of the Tide Water Corp., New York, following his recent resignation from the National Aniline & Chemical Co., Inc.

BRADLEY STOUGHTON, formerly secretary of the American Institute of Mining and Metallurgical Engineers, was elected president of the Yale Engineering Association at the annual meeting on Feb. 2, 1922.

Obituary

THOMAS FRANCIS CROWLEY, for about half a century past prominently identified in an official capacity with the Lambertville Rubber Co., Lambertville, N. J., died at his residence in that city, Jan. 29, at the age of seventy-four years.

CHARLES LEWIS TAYLOR, E.M., Eng.D., prominent as a metallurgist, chemist and philanthropist, died on Feb. 3 at his winter home in Santa Barbara, Cal. Mr. Taylor was born in Philadelphia on April 3, 1857, and was graduated from Lehigh University in the class of 1876. He was connected with the Cambria Iron Co. at Johnstown, Pa., as assistant chemist and later as assistant superintendent of blast furnaces. He was superintendent of the Homestead works of the Pittsburgh Bessemer Steel Co. from 1882 to 1886 and the development of the present methods of production of steel pipe, nails and ship plate was due largely to his ability as a chemist and metallurgist. He was general manager of the Hartman Steel Co. of Pittsburgh until 1890, when he became associated with Andrew Carnegie in the firm of Carnegie, Phipps & Co., Ltd., and later became Mr. Carnegie's assistant in the Carnegie Steel Co. Mr. Taylor retired from active business in 1901 and devoted his time and energy to philanthropic work. He was president of the Carnegie Hero Fund Commission and chairman of the Carnegie Relief Fund from the time of their foundation in 1904. He was also a trustee of the Carnegie Peace Fund, the Carnegie Library, Carnegie Institute, Carnegie Institute of Technology and Lehigh University. In his biography Mr. Carnegie states, in referring to a dormitory building donated by him and named in honor of Mr. Taylor: "Visitors who may look upon that structure and wonder who Taylor was may rest assured that he was a loyal son of Lehigh, a working, not merely a preaching, apostle of the gospel of service to his fellow men and one of the best men that ever lived."

Market Conditions

IN CHEMICAL, METALLURGICAL AND ALLIED INDUSTRIES

A Survey of the Economic and Commercial Factors That Influence Trade in Chemicals and Related Commodities—Prevailing Prices and Market Letters From Principal Industrial Centers

Statistics of Chemical Production

The study and compilation of the statistics collected for the 1919 census of manufactures have now proceeded to the stage where accurate comparisons can be made with the results of prior censuses. Through the courtesy of the Bureau of the Census, certain of the chemical industries are now being furnished with detailed statistics in approximately the form in which they will appear in the tables of the forthcoming Abstract. Revisions have been made in many of the preliminary totals published in CHEMICAL & METALLURGICAL ENGINEERING for Sept. 7, 1921, and much additional information is included, notably that regarding the number of establishments, and the production for sale and for direct consumption. The final report of the Census Bureau will show the distribution of these establishments by states and cities as well as detailed data concerning the number of wage earners, power and fuel consumption, etc.

From time to time it is our intention to publish the more important of these statistics as they relate to the chemical and allied industries. It is unnecessary, perhaps, to point out that the value of the 1919 figures lies principally in their relation to our maximum peace-time production. In other words, they represent capacities of these industries after most, if not all, of the war-time activities had been discontinued. In the case of some chemical products, the maximum rate of output was probably reached in 1920, while in the cases of others, the consumption of war-time reserves inhibited production both in 1919 and 1920. However, it is believed that 1919 is a satisfactory year for comparing productive capacity with that of 1914 and of 1909.

THE ACID INDUSTRIES, 1909—1919

The detailed statistics for the production of the principal acids during the last three census years are compared in the accompanying tabulation. It will be noted that the total value of products increased from $32,837,254 in 1914 to $87,011,618 in 1919. It would appear at first glance that our output of these products had more than doubled, but when correction is made for the greatly increased prices of 1919 it will be observed that the increase is but slightly more than that which occurred during the 5-year period 1909-1914. The CHEM. & MET. Index of Chemical Prices for 1919 was 242 per cent of 1913-1914 figures. If the value of the 1914 production is increased in this proportion, we obtain the figure $79,500,000, which is only approximately 7.5 million dollars less than the reported value of the 1919 output. The increase between 1909 and 1914 was about 6.8 million dollars.

The output of the inorganic acids in 1919 showed less relative increase than did the organic acids. However, the quantities reported for each of the individual acids increased with the exception of hydrofluoric, acetic, tannic and certain strengths of sulphuric acid. In several instances there are decreases in the number of establishments, indicating larger scale of operations and possible merging of producing interests.

CHEMICAL & METALLURGICAL ENGINEERING'S WEIGHTED INDEX OF CHEMICAL PRICES

Base = 100 for the year July 1, 1913, to June 30, 1914

This week	147.46
Last week	147.33
February, 1921	166
February, 1920	252
April, 1918 (high)	286
April, 1921 (low)	140

The index number remains practically unchanged notwithstanding the continued strength of the vegetable oil markets. The higher prices for cottonseed and linseed oils were almost entirely offset by the lower figures quoted for hydrochloric acid, bleaching powder, soda ash, caustic soda and caustic potash.

PRODUCTION OF PRINCIPAL ACIDS IN 1919 COMPARED WITH PRODUCTION IN 1909 AND 1914.

(Census of Manufactures, 1919)

	1919	1914	1909
Value of products	$87,011,618	$32,837,254	$26,068,617
INORGANIC ACIDS, value	$59,875,958	$25,082,873	.....
Arsenic and arsenious acids:			
Number of establishments	10	.....	.....
Total production, lb.	3,100,389	.....	.....
For sale:			
Lb.	1,076,000	(1)	(1)
Value	$108,233	.....	.....
Made and consumed, lb.	2,024,389	.....	.....
Boric acid:			
Number of establishments	6	5	5
Lb.	13,454,100	8,584,311	5,554,914
Value	$1,754,632	$588,981	$295,776
Unit value, lb.	$0.12	$0.07	$0.06
Carbonic acid (carbon dioxide, CO_2)			
Number of establishments	42	38	35
Lb.	59,771,411	50,445,779	47,953,291
Value	$6,574,250	$2,320,685	$2,345,743
Unit value, lb.	$0.11	$0.04	$0.05
Hydrochloric acid:			
Number of establishments	39	31	38
Total production, tons	221,613	168,584	122,367
For sale:			
Tons	150,090	85,438	101,607
Value	$4,312,253	$1,348,805	$1,758,335
Unit value, ton	$29	$16	$17
Made and consumed, lb.	71,523	83,145	20,760
Hydrofluoric acid:			
Number of establishments	6	9	10
Total production, lb.	5,732,198	7,209,248	8,027,290
For sale:			
Lb.	4,320,017	5,373,657	6,842,914
Value	$440,184	$325,540	$294,379
Unit value, lb.	$0.10	$0.06	$0.04
Made and consumed, lb.	1,412,181	1,835,591	1,184,376
Mixed acid (sulphuric-nitric):			
Number of establishments	23	37	14
Total production, tons	114,886	112,124	.....
For sale:			
Tons	46,428	42,725	28,591
Value	$4,426,637	$2,204,480	$1,860,787
Unit value, ton	$95	$51	$65
Made and consumed, tons	68,458	69,399	.....
Nitric acid:			
Number of establishments	42	52	25
Total production, tons	86,992	78,589	68,717
For sale:			
Tons	19,436	14,685	13,663
Value	$2,976,095	$1,591,625	$1,357,098
Unit value, ton	$153	$108	$99
Made and consumed, tons	67,556	63,904	55,054
Phosphoric acid:			
Number of establishments	9	7	9
Total production, lb.	22,109,302	.....	.....
For sale:			
Lb.	13,379,501	12,420,191	.....
Value	$1,711,148	$680,239	$667,505
Unit value, lb.	$0.13	$0.05	.....
Made and consumed, lb.	8,729,801	.....	.....
Sulphuric acid:			
Number of establishments	208	194	183
Total production, reduced to 50 deg. Bé., tons	5,402,347	4,071,566	2,764,455
For sale:			
Tons	3,190,333	2,338,284	1,479,200
Value	$34,559,252	$15,395,133	$10,103,425
Unit value, ton	$10.32	$6.58	$6.89
Made and consumed, tons	2,212,014	1,733,282	1,285,255
Production according to strength:			
For sale:			
50 deg. Bé.			
Tons	845,346	451,121	528,263
Value	$9,626,608	$2,709,350	$3,176,430
60 deg. Bé.			
Tons[2]	943,805	545,562	177,414
Value	$9,415,310	$3,754,866	$1,038,358
60 deg. Bé.			
Tons	704,070	732,186	453,370
Value	$13,521,316	$8,042,422	$5,454,002
Oleum or fuming:			
Tons[3]	63,816	62,354	28,594
Value	$1,996,018	$888,495	$434,635
Unit value, ton	$31	$14	$15

PRODUCTION OF PRINCIPAL ACIDS IN 1919 COMPARED WITH PRODUCTION IN 1909 AND 1914 (Continued)

(Census of Manufactures, 1919)

	1919	1914	1909
Made and consumed, tons:			
50 deg. Bé.	1,911,331	1,250,112	1,115,018
60 deg. Bé.	70,681	249,927	11,970
66 deg. Bé.	126,892	96,280	99,249
Oleum or fuming	12,862	15,404	3,743
Sulphur trioxide (sulphuric anhydride):			
Number of establishments	4	.....	.....
Total production, tons	74,213	.....	.....
For sale:			
Tons	68,926	(4)	(4)
Value	1,373,353	.....	.....
Made and consumed, tons	5,287	.....	.....
Sulphuric acid, reclaimed:			
Number of establishments	11	14	.....
Total production, tons	134,513	.....	.....
For sale:			
Tons	95,119	136,360	7,069
Value	$803,144	$518,890	$62,935
Made and consumed, tons	39,394	.....	.....
ORGANIC ACIDS, value	$27,135,660	$7,754,381	.....
Acetic acid, value	$4,264,044	$1,272,294	.....
Acetic, dilute and pyroligneous:			
Number of establishments	16		
Total production, lb.	56,585,386		
For sale:			
Pounds	46,820,736		
Value	$2,816,252		
Unit value, lb.	$0.06		
Made and consumed, lb.	9,764,650		
Acetic, glacial			
Number of establishments	4	14	13
Total production, lbs.	5,794,904	75,503,375	58,000,602
For sale:			
Lb.	5,482,000	70,817,637	56,923,773
Value	$869,196	$1,272,294	$1,336,874
Unit value, lb.	$0.15	.....	.....
Made and consumed, lb.	312,904	4,685,738	1,076,829
Acetic anhydride:			
Number of establishments	7		
Total production, lb.	1,794,985		
For sale:			
Lb.	1,213,861		
Value	$578,596		
Unit value, lb.	$0.47		
Made and consumed, lb.	581,124		
Citric acid:			
Number of establishments	6	3	5
Total production, lb.	3,260,4[illegible]	2,729,943	.....
For sale:			
Lb.	3,163,676	2,657,840	2,102,256
Value	$3,047,371	$1,516,336	$777,235
Unit value, lb.	$0.96	$0.57	$0.37
Made and consumed, lb.	96,806	72,103	.....
Lactic acid:			
Number of establishments	.....	.....	.....
Value	$781,828	(1)	(1)
Oleic acid:			
Number of establishments	11	7	8
Total production, lb.	44,895,453	23,187,579	.....
For sale:			
Lb.	44,350,574	21,932,736	16,377,063
Value	$6,548,564	$1,301,353	$845,106
Unit value, lb.	$0.15	$0.06	$0.05
Made and consumed, lb.	544,879	1,254,843	.....
Stearic acid:			
Number of establishments	11	10	11
Total production, lb.	20,149,988	14,960,109	.....
For sale:			
Lb.	20,071,445	14,351,404	.....
Value	$4,613,862	$1,242,492	$1,143,213
Unit value, lb.	$0.22	$0.09	.....
Made and consumed, lb.	78,543	608,705	.....
Tannic acid:			
Number of establishments	4	5	.....
Lb.	845,065	853,830	(1)
Value	$746,825	$287,142	
Unit value, lb.	$0.88	$0.34	.....
Tartaric acid:			
Number of establishments	4	.....	.....
Lb.	5,312,965	(1)	(1)
Value	$4,262,376	.....	.....
Other acids:			
Inorganic[5]	$836,777	$108,495	$3,220,206
Organic[6]	$2,870,790	$2,417,906	

1 Not separately reported.
2 Includes a large production under a long-term, low-priced contract.
3 Includes "Battery acid" and "Electrolyte sulphuric." 4,694 tons.
4 Included above with oleum.
5 Includes, 1919, chlorsulphuric, chromic, hydrobromic, hydrofluosilicic, hydrophosphorous, molybdic, silicic, tungstic, vanadic, etc., and for 1914, sulphurous, hypophosphorous, arsenic and hydrofluosilicic.
6 Includes, 1919, butyric, caproic, carbolic, oresylic, formic, gallic, glycerophosphoric, hydrocyanic, monochloracetic, oxalic, phthalic anhydride, propionic, pyrogallic, thymol and valerianic.

Mathieson Alkali Works to Show Deficit for 1921

The forthcoming annual report of the Mathieson Alkali Works is expected to show a deficit of about $200,000 after the charges have been made to the depreciation account. It is reported that since October the company has been operating at a profit and at the present time its earnings are at the rate of about $8 per share on its common stock.

Recent Activity of Davison Stock

The recent advances in the quotations for the stock of the Davison Chemical Co. have occasioned considerable interest in the activities of the company as well as of its subsidiary, the Silica Gel Corporation. The stock of the Davison company advanced to 62⅜ on Jan. 25 and at the end of the day had shown a net gain of 5⅜ points. Since that time the stock has been held at 60 or above. Although there is considerable mystery surrounding the present flurry, it is generally believed that the activity is a direct result of certain negotiations between the Davison company and the Persian Oil Co. of Great Britain, which is said to be interested in using the silica-gel process for refining gasoline. The process is now being tried out on a considerable scale in the East Braintree (Mass.) plant of the Island Oil & Transport Co.

Recent financial statements of the Davison Chemical Co. are not available, but according to the *Wall Street Journal*, the net earnings of $822,602 for the year ended Dec. 31, 1920, were equal to $4.11 a share on the outstanding 200,000 shares of stock of no par value, after deductions had been made for expenses, interest, depreciation and revaluation of ore stocks in Cuba. In 1919 the earnings were $1.91 per share. It should be pointed out, however, that these profits are based on the company's business in sulphuric acid and acid phosphate. As yet there have been no earnings from the Silica Gel Corporation.

The New York Market

NEW YORK, Feb. 13, 1922.

The chemical market during the past week showed little signs of recovering and in general transactions were limited to orders for immediate requirements. Miscellaneous chemicals were more active during recent sales, but prices in many instances had to be sacrificed. Producers of late are acquiring most of the regular consuming business.

The alkali trade is apparently well covered by standing contracts as far as the leading consumers are concerned and competition on any new business of sizable proportions is extremely keen. The export situation on caustic soda is a trifle better with several new transactions reported to Italy and Japan. A feature in the alkali market was the entry of Germany as a buyer of caustic soda. Recent internal disturbances are said to be the cause of the purchases of that country. South American markets have not shown any signs of real activity, but it is believed that Argentina will probably offer a market as soon as conditions have become more sound. Other countries are buying alkalis in a moderate way.

In many instances large quantities of imported chemicals have been offered in the open market at prices which represent heavy losses to the importers. Among these products are cyanide of soda, chlorate of soda, caustic potash, citric acid, salammoniac and others. The principal explanation for this situation has been the irregular delivery and poor quality of the foreign goods. Preference for American cyanide and salammoniac has recently been shown in several transactions where buyers paid the differential as an assurance for quality and delivery.

GENERAL CHEMICALS

Bleaching powder is becoming more irregular under a keener state of first-hand competition. Orders for domestic consumption were accepted by producers at 2c. per lb., f.o.b. works. Bichromate of soda was steadier on spot with only a small-lot inquiry being noted. It is doubtful if better than 7⅞c. per lb. could be obtained. Prussiate of soda sold at lower prices, with sales reported down to 16¾c. per lb. Shipments were also quoted at this figure c.i.f. N. Y. The demand was not as active as earlier in the year. Oxalic acid is holding steady both on spot and at the works. Prices have remained firm on spot at 14½@15c. per lb., with works material held around 14c. Sales of yellow prussiate of potash were recorded during the week at 24¾@25c. per lb., with the higher figure generally asked by most sellers of spot material. The red variety is entirely nominal, owing to the scarcity of supplies.

Resale lots of imported caustic potash, 88-92 per cent, are in the market at $5.55 per 100 lb., and it is understood that sales have been made down to 5½c. per lb. It is surprising to note the decline in prices on this chemical when existing conditions seem to show every tendency to advance it. There is a steady absorption of resale material owing to a firmer condition developing in the German market and the fact that leading importers feel very doubtful if stock can be replenished at current quotation. Export inquiries on caustic soda have been sufficiently active to permit dealers to place some business, although prices have been subject to shading. Dealers quoted $3.35 @$3.40 per 100 lb. f.a.s. Some of the larger interests quote the market around $3.45. Nitrite of soda was reported very scarce on spot by leading factors, with a noticeably improved inquiry. Prominent sellers refused to shade 7c. per lb. at the close of the week and several sales of carload quantities were recorded at this figure. Prices of domestic soda ash on spot have drifted to a slightly lower level, single bags being offered at $1.65 per 100 lb. in carload lots.

LINSEED OIL

There was a substantial rise recorded in linseed oil when the market closed at 78c. per gal. in barrels for carlots. The rising market, however, did not bring with it much new business, most consumers evidently being covered for February-March-April. Imported oil was subject to some violent fluctuations, business passing at prices ranging from 58@63c. per gal., duty unpaid, c.i.f. New York, for February-March shipment from abroad.

The Chicago Market

CHICAGO, Feb. 10, 1922.

The heavy chemical market continues exceedingly quiet, with no developements worthy of notice. Buyers show a pronounced reluctance to come into the market and are buying only very small supplies for immediate consumption. A variety of prices are obtainable from the small brokers, but manufacturers or their agents are making no effort to meet this competition. It is noticeable that many buyers will pay a somewhat higher price for an item from a manufacturer rather than go to a small dealer or broker. Supplies of most items are only moderate, although it is said that a few speculators are carrying rather heavy stocks.

GENERAL CHEMICALS

The alkali situation is unchanged, with spot stocks only moderate and current quotations unchanged. There is little doubt that prices could be shaded with firm business. Ground caustic soda, 76 per cent, is quoted at $4.50 per 100 lb. and the solid at $3.75. Soda ash continues quiet and is offered at $2.30 per 100 lb. for medium-sized lots in cooperage. There is a small amount of caustic potash moving and the price is firm at 6½c. per lb. for the 88-92 per cent material.

Potash alum is quiet on spot, with only small lots moving. the lump is quoted at 5½@6c. per lb. and the powdered at 6@6½c. Iron-free aluminum sulphate is slow and unchanged at 3½c. per lb. White arsenic continues firm with only small quantities available at 8@8½c. per lb. Barium chloride is obtainable on spot at $55 per ton but little is moving. Small quantities of blue vitriol changed hands at 6c. per lb. but nothing of any consequence was reported. Holders report a fair demand for borax, which is quoted at 6c. per lb. for single barrels. Carbon bisulphide is very quiet and spot stocks are still quoted at 7@7½c. per lb. Carbon tetrachloride is in a similar position and large drums are offered at 11c. per lb. Glycerine is very firm, with c.p. material quoted by refiners at 16½@17c. per lb., bulk basis. Epsom salts attract little attention and are quoted at 2¾c. per lb. for U.S.P. material in barrels.

Bichromates are enjoying a fair demand for small lots and are unchanged as to price. Potash bichromate is offered at 11¾c. per lb. in single casks and similar lots of the soda at 9½c. Red prussiate of potash is entirely off the market and not a single pound could be located. Single casks were offered to arrive at 52@55c. per lb. Yellow prussiate of potash is firm at 26@27c. acording to quantity and holder. Potassium permanganate is very slow with spot U.S.P. crystals quoted in small lots at 17@18c. per lb. Hypo is very quiet at $3.95 per 100 lb. for pea crystals in barrels.

VEGETABLE OILS AND NAVAL STORES

Linseed oil is reported to be moving very slowly, although the price is showing unusual firmness. The boiled oil is quoted at 82c. per gal. in 5-bbl. lots and similar quantities of the raw at 80c. Higher prices on this oil are freely predicted by all factors.

Turpentine, like linseed oil, while very firm as to price, is moving very slowly. Pure spirits are quoted in 5-drum lots at 96c. per gal. Rosin is showing firmness and is said to be moving fairly well to the paper trade. Prices lacked quotable change and were only nominal for less than carlots.

The Iron and Steel Market

PITTSBURGH, Feb. 10, 1922.

The improvement in the volume of steel orders placed since the first of the year is found by the January ingot production report to have been greater than commonly estimated. The American Iron and Steel Institute's report, giving the production of steel ingots in January by the thirty reporting companies, indicates that production by the industry as a whole was at the rate of about 22,750,000 tons per annum during January. The average production during December was about 19,750,000 tons, and as production during December was declining, the rate at the close of the month was much less, probably between 16,000,000 and 18,000,000 tons. From such a rate there has been a more or less progressive increase to date, and with a January average of about 22,750,000 tons the rate by this time may be close to 25,000,000 tons. If so, we have already exceeded the high level of last autumn, shown by a production rate of 23,000,000 tons during October and November. Meanwhile there has been a lull, which is to be attributed to its being winter rather than to the much mentioned holidays and annual inventory.

Competition for steel orders continues keen. The openly quoted or "regular" prices are practically unchanged, but the average price realized on all the tonnage sold has probably been sagging a trifle from week to week. The extreme prices may be much the same, but smaller and smaller orders, in many commodities, become subject to concessions from the "regular" prices. Apart from general shading, there is the case of mills well removed from Pittsburgh departing from "Pittsburgh plus." Chicago has long had its own basing for bars, shapes and plates, 1.60c., as against a Pittsburgh market of 1.50c., while by "Pittsburgh plus" the Chicago market would be 1.88c., the freight Pittsburgh to Chicago being 38c. per 100 lb. Of late the East has likewise departed, Eastern mills making delivered prices which Pittsburgh producers do not meet when they represent extreme concessions.

PIG IRON AND COKE

In most districts pig iron continues to show a slight sagging tendency, with now and then a definite, though small, decline. Many buyers doubt whether prices are really below cost of production, as so generally claimed by furnaces.

Connellsville coke has undergone a sharp stiffening in the past week, mostly because of the threatened suspension at the union bituminous coal mines April 1. The trade generally regards the suspension as assured, and assumes that the non-union mines will not be able to supply the entire demand. Some foundries are stocking foundry coke, while Connellsville coke operators are turning their attention to coal, which even at recent prices has been bringing more as coal than when made into coke. Spot furnace coke of fair grade could be had a week ago at $2.75, while at present no passable coke is available at under $2.85 and the best grades command $3. Foundry coke remains quotable at $3.75@$4.25, but there is little at the lower prices and much more request for the $4.25 brands.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.	–	$0.40 – $0.42
Acetone	lb.	$0.12½ – $0.12½	.13 – .13½
Acid, acetic, 28 per cent	100 lbs.	2.50 – 2.60	2.65 – 3.00
Acetic, 56 per cent	100 lbs.	5.00 – 5.25	5.30 – 5.50
Acetic, glacial, 99½ per cent, carboys, 100 lbs.		9.00 – 9.50	9.75 – 10.00
Boric, crystals	lb.	.12½ – .12½	.13 – .13½
Boric, powder	lb.	.12½ – .13	.13½ – .14
Citric	lb.	–	.44 – .45
Hydrochloric	100 lb.	1.15 – 1.25	1.30 – 1.75
Hydrofluoric, 52 per cent	lb.	.11 – .11½	.11 – .12
Lactic, 44 per cent tech	lb.	.09½ – .10	.10½ – .12
Lactic, 22 per cent tech	lb.	.04 – .04½	.04½ – .05
Molybdic, c.p.	lb.	3.00 – 3.25	3.30 – 3.75
Muriatic, 20 deg. (see hydrochloric)		–	–
Nitric, 40 deg.	lb.	.06½ – .06½	.06½ – .07
Nitric, 42 deg.	lb.	.06½ – .07	.07½ – .07½
Oxalic, crystals	lb.	.14½ – .15	.15½ – .16
Phosphoric, 50 per cent solution	lb.	.08½ – .08½	.09 – .10
Picric	lb.	.20 – .25	.27 – .35
Pyrogallic, resublimed	lb.	–	1.65 – 1.75
Sulphuric, 60 deg., tank cars	ton	10.00 – 11.00	–
Sulphuric, 60 deg., drums	ton	12.00 – 14.00	–
Sulphuric, 66 deg., tank cars	ton	16.00 – 16.50	–
Sulphuric, 66 deg., drums	ton	20.00 – 20.50	21.00 – 22.00
Sulphuric, 66 deg., carboys	ton	–	–
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	19.50 – 20.00	–
Sulphuric, fuming, 20 per cent (oleum) drums	ton	22.00 – 22.50	23.00 – 24.00
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	31.00 – 32.00	33.00 – 34.00
Tannic, U. S. P.	lb.	–	.65 – .75
Tannic (tech.)	lb.	.45 – .50	.51 – .55
Tartaric, imported crystals	lb.	–	.25½ – .27
Tartaric acid, imported, powdered	lb.	–	.26 – .29
Tartaric acid, domestic	lb.	–	– .30
Tungstic, per lb. of WO	lb.	–	1.00 – 1.10
Alcohol, ethyl	gal.	–	4.75 – 5.50
Alcohol, methyl (see methanol)		–	–
Alcohol, denatured, 188 proof	gal.	–	.39 – .40
Alcohol, denatured, 190 proof	gal.	–	.40 – .41
Alum, ammonia, lump	lb.	.03½ – .03¾	.04 – .04½
Alum, potash, lump	lb.	.03½ – .04	.04½ – .04¾
Alum, chrome lump	lb.	.07½ – .08	.08½ – .08¾
Aluminum sulphate, commercial	lb.	.01½ – .02	.02½ – .02¾
Aluminum sulphate, iron free	lb.	.02½ – .02¾	.03 – .03¾
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.07½ – .07¾	.08 – .08½
Ammonia, anhydrous, cyl. (100-150 lb.)	lb.	.30 – .30½	.31 – .33
Ammonium carbonate, powder	lb.	.07 – .07½	.08 – .09
Ammonium nitrate	lb.	.06½ – .07	.07½ – .07¾
Amylacetate tech.	gal.	–	2.00 – 2.40
Arsenic, white, powdered	lb.	.07½ – .07¾	.07¾ – .08¾
Arsenic, red, powdered	lb.	.12 – .12½	.12½ – .13
Barium chloride	ton	54.00 – 55.00	55.50 – 70.00
Barium dioxide (peroxide)	lb.	.21 – .21½	.22 – .23
Barium nitrate	lb.	.06½ – .07	.07½ – .08½
Barium sulphate (precip.) (blanc fixe)	lb.	.03½ – .04	.04½ – .04½
Blanc fixe, dry	lb.	.04 – .04½	–
Blanc fixe, pulp	ton	45.00 – 55.00	–
Bleaching powder	100 lb.	2.10 – 2.25	2.30 – 3.25
Blue vitriol (see copper sulphate)		–	–
Borax	lb.	.05½ – .06	.06½ – .07
Brimstone (see sulphur, roll)		–	–
Bromine	lb.	.20 – .21	.21½ – .26
Calcium acetate	100 lbs.	1.75 – 2.00	–
Calcium carbide	lb.	.04½ – .04½	.05 – .05½
Calcium chloride, fused, lump	ton	24.00 – 24.50	24.75 – 27.00
Calcium chloride, granulated	lb.	.01½ – .02	.02½ – .02½
Calcium peroxide	lb.	–	1.40 – 1.50
Calcium phosphate, tribasic	lb.	–	.15 – .16
Camphor	lb.	–	.96 – .98
Carbon bisulphide	lb.	.06 – .06½	.06½ – .07½
Carbon tetrachloride, drums	lb.	.10½ – .10¾	.11 – .12
Carbonyl chloride, (phosgene)	lb.	–	.60 – .75
Caustic potash (see potassium hydroxide)		–	–
Caustic soda (see sodium hydroxide)		–	–
Chalk, precip.—domestic, light	lb.	.04½ – .04¾	–
Chalk, precip.—domestic, heavy	lb.	.03½ – .03¾	–
Chalk, precip.—imported, light	lb.	.04½ – .05	–
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.06 – .06½	.06½ – .07
Chloroform	lb.	–	.37 – .40
Cobalt oxide	lb.	–	2.00 – 2.10
Copperas	ton	15.00 – 16.00	16.50 – 20.00
Copper carbonate, green precipitate	lb.	.20 – .20½	.21 – .21½
Copper cyanide	lb.	–	.58 – .60
Copper sulphate, crystals	100 lb.	5.55 – 5.65	5.70 – 6.25
Cream of tartar	lb.	–	.23 – .24½
Epsom salt (see magnesium sulphate)		–	–
Ethyl acetate com. 85%	gal.	–	.58 – .65
Ethyl acetate, pure (acetic ether, 98% to 100%)	gal.	–	.93 – –
Formaldehyde, 40 per cent	lb.	.10 – .10½	.10½ – .11½
Fullers earth, f.o.b. mines	net ton	16.00 – 17.00	–
Fullers earth—imported powdered—net	ton	30.00 – 32.00	–
Fusel oil, ref.	gal.	–	2.50 – 3.00
Fusel oil, crude	gal.	–	1.40 – 1.75
Glauber's salt (see sodium sulphate)		–	–
Glycerine, c. p. drums extra	lb.	–	.16½ – .17
Iodine, resublimed	lb.	–	3.80 – 3.90
Iron oxide, red	lb.	–	.12 – .18
Lead acetate	lb.	–	.10½ – .12½
Lead arsenate, powd.	lb.	.15 – .15½	.15½ – .16½
Lead nitrate	lb.	–	.15 – .20
Litharge	lb.	.07½ – .07½	.08 – .08½
Magnesium carbonate, technical	lb.	.06 – .06½	.06½ – .08
Magnesium sulphate, U. S. P.	100 lb.	2.65 – 2.70	2.75 – 3.00
Magnesium sulphate, technical	100 lb.	–	1.05 – 1.80
Methanol, 95%	gal.	–	.60 – .62
Methanol, 97%	gal.	–	.62 – .63
Nickel salt, double	lb.	–	.11 – .11½
Nickel salt, single	lb.	–	.11 – .11½
Phosgene (see carbonyl chloride)		–	–
Phosphorus, red	lb.	.45 – .46	.47 – .50
Phosphorus, yellow	lb.	–	.30 – .35

		Carlots	Less Carlots
Potassium bichromate	lb.	.10¼ – .10½	.10½ – .11
Potassium bromide, granular	lb.	–	.13 – .17
Potassium carbonate, U. S. P.	lb.	.12 – .12½	.13 – .16
Potassium carbonate, 80-85%	lb.	.04½ – .04½	.05 – .06
Potassium chlorate, crystals	lb.	.05¼ – .05½	.05½ – .08
Potassium cyanide	lb.	–	.42 – .45
Potassium hydroxide (caustic potash)	100 lb.	5.55 – 5.65	5.70 – 6.50
Potassium iodide	lb.	–	2.90 – 3.00
Potassium nitrate	lb.	.07½ – .07½	.08 – .09
Potassium permanganate	lb.	.13 – .14	.14½ – .22
Potassium prussiate, red	lb.	nominal	nominal
Potassium prussiate, yellow	lb.	.24 – .25	.25½ – .25½
Rochelle salts (see sodium potas tartrate)		–	–
Salammoniac, white, granular	lb.	.06½ – .07	.07½ – .07½
Salammoniac, gray, granular	lb.	.06½ – .06¾	.07 – .07½
Salsoda	100 lb.	1.60 – 1.70	1.75 – 2.00
Salt cake (bulk)	ton	17.00 – 20.00	–
Soda ash, light	100 lb.	1.65 – 1.80	1.85 – 2.40
Soda ash, dense	100 lb.	1.75 – 1.85	1.90 – 2.40
Sodium acetate	lb.	.04 – .04½	.04½ – .05
Sodium bicarbonate	100 lb.	2.20 – 2.25	2.30 – 2.75
Sodium bichromate	lb.	.07½ – .08	.08½ – .08½
Sodium bisulphate (nitre cake)	ton	4.50 – 4.60	4.65 – 5.50
Sodium bisulphite powdered, U.S.P.	lb.	.04½ – .04¾	.05 – .05½
Sodium chlorate	lb.	.06½ – .06¾	.07 – .07½
Sodium chloride	long ton	12.00 – 13.00	–
Sodium cyanide	lb.	.26 – .26½	.26½ – .27
Sodium fluoride	lb.	.08 – .08½	.08½ – .09½
Sodium hydroxide (caustic soda)	100 lb.	3.35 – 3.40	3.45 – 4.10
Sodium hyposulphite	lb.	.03¼ – .03½	.03½ – .04
Sodium nitrite	lb.	.07 – .07½	.07½ – .08
Sodium peroxide, powdered	lb.	.28 – .30	.31 – .35
Sodium phosphate, dibasic	lb.	.03½ – .04	.04½ – .04½
Sodium potassium tartrate (Rochelle salts)	lb.	–	.18 – .21
Sodium prussiate, yellow	lb.	.16½ – .17	.17½ – .17½
Sodium silicate, solution (40 deg.)	100 lb.	.85 – 1.00	1.05 – 1.15
Sodium silicate, solution (60 deg.)	100 lb.	2.25 – 2.40	2.45 – 2.75
Sodium sulphate, crystals (glaubers salt)	100 lbs.	1.25 – 1.30	1.35 – 2.00
Sodium sulphide, fused, 60-62 per cent (conc.)	lb.	.04½ – .04½	.04½ – .05
Sodium sulphite, crystals	lb.	.03½ – .03¾	.03½ – .04½
Strontium nitrate, powdered	lb.	.10 – .11	.11½ – .15
Sulphur chloride, red	lb.	.05 – .05½	.05½ – .06
Sulphur, crude	ton	18.00 – 20.00	–
Sulphur dioxide, liquid, cylinders extra	lb.	.08 – .08½	.09 – .10
Sulphur (sublimed), flour	100 lb.	–	2.25 – 3.10
Sulphur, roll (brimstone)	100 lb.	–	2.00 – 2.75
Talc—imported	ton	30.00 – 40.00	–
Talc—domestic powdered	ton	18.00 – 25.00	–
Tin bichloride	lb.	.09 – .09½	.09½ – .10
Tin oxide	lb.	–	.39 – .40
Zinc carbonate	lb.	.15 – .15½	.15½ – .16
Zinc chloride, gran.	lb.	.08 – .08½	.08½ – .09
Zinc cyanide	lb.	.42 – .44	.45 – .47
Zinc oxide, XX	lb.	.07½ – .08	.08½ – .08½
Zinc sulphate	100 lb.	3.00 – 3.25	3.30 – 3.50

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha-naphthol, crude	lb.	$1.00 — $1.05
Alpha-naphthol, refined	lb.	1.10 — 1.15
Alpha-naphthylamine	lb.	.28 — .33
Aniline oil, drums extra	lb.	.17 — .18
Aniline salts	lb.	.24 — .25
Anthracene, 80% in drums (100 lb.)	lb.	.75 — 1.00
Benzaldehyde U.S.P.	lb.	1.30 — 1.35
Benzidine, base	lb.	.85 — .95
Benzidine sulphate	lb.	.75 — .85
Benzoic acid, U.S.P.	lb.	.60 — .65
Benzoate of soda, U.S.P.	lb.	.55 — .57
Benzene, pure, water-white, in drums (100 gal.)	gal.	.29 — .35
Benzene, 90%, in drums (100 gal.)	gal.	.27 — .32
Benzyl chloride, 95-97%, refined	lb.	.25 — .27
Benzyl chloride, tech.	lb.	.20 — .23
Beta-naphthol benzoate	lb.	3.75 — 4.00
Beta-naphthol, sublimed	lb.	.60 — .65
Beta-naphthol, tech	lb.	.29 — .32
Beta-naphthyla mine, sublimed	lb.	1.50 — 1.60
Cresol, U. S. P., in drums (100 lb.)	lb.	.16 — .17
Ortho-cresol, in drums (100 lb.)	lb.	.20 — .22
Cresylic acid, 97-99%, straw color, in drums	gal.	.50 — .52
Cresylic acid, 95-97%, dark, in drums	gal.	.45 — .47
Dichlorbenzene	lb.	.06 — .09
Diethylaniline	lb.	1.00 — 1.10
Dimethylaniline	lb.	.41 — .45
Dinitrobenzene	lb.	.21 — .25
Dinitroclorbenzene	lb.	.25 — .27
Dinitronaphthalene	lb.	.32 — .35
Dinitrophenol	lb.	.35 — .38
Dinitrotoluene	lb.	.25 — .30
Dip oil, 25%, car lots, in drums	gal.	.28 — .30
Diphenylamine	lb.	.60 — .70
H-acid	lb.	.90 — 1.00
Meta-phenylenediamine	lb.	1.00 — 1.05
Monochlorbenzene	lb.	.10 — .12
Monoethylaniline	lb.	1.15 — 1.20
Naphthalene crushed, in bbls.	lb.	.07 — .08
Naphthalene, flake	lb.	.07 — .08
Naphthalene, balls	lb.	.08 — .09
Naphthionic acid, crude	lb.	.65 — .70
Nitrobenzene	lb.	.10 — .12
Nitro-naphthalene	lb.	.30 — .35
Nitro-toluene	lb.	.15 — .17½
Ortho-amidophenol	lb.	2.75 — 2.80
Ortho-dichlor-benzene	lb.	.15 — .20
Ortho-nitro-phenol	lb.	.75 — .80
Ortho-nitro-toluene	lb.	.15 — .20
Ortho-toluidine	lb.	.20 — .25
Para-amidophenol, base	lb.	1.25 — 1.30
Para-amidophenol, HCl	lb.	1.35 — 1.40
Para-dichlorbenzene	lb.	.17 — .18
Paranitroaniline	lb.	.77 — .80
Para-nitrotoluene	lb.	.70 — .75
Para-phenylenediamine	lb.	1.60 — 1.65
Para-toluidine	lb.	1.10 — 1.15
Phthalic anhydride	lb.	.37 — .40
Phenol, U. S. P., drums	lb.	.12 — .16

Pyridine	gal.	1.75 —	2.75
Resorcinol, technical	lb.	1.30 —	1.35
Resorcinol, pure	lb.	1.85 —	2.00
Salicylic acid, tech., in bbls.	lb.	.18 —	.20
Salicylic acid, U. S. P.	lb.	.22 —	.23
Salol	lb.	.80 —	.82
Solvent naphtha, water-white, in drums, 100 gal.	gal.	.25 —	.28
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.12 —	.14
Sulphanilic acid, crude	lb.	.26 —	.28
Tolidine	lb.	1.20 —	1.30
Toluidine, mixed	lb.	.32 —	.38
Toluene, in tank cars	gal.	.25 —	.28
Toluene, in drums	gal.	.30 —	.35
Xylidines, drums, 100 gal.	lb.	.40 —	.45
Xylene, pure, in drums	gal.	.40 —	.45
Xylene, pure, in tank cars	gal.	.45 —	.....
Xylene, commercial, in drums, 100 gal.	gal.	.33 —	.35
Xylene, commercial, in tank cars	gal.	.30 —	.....

Waxes

Stearic Acid, single pressed	lb.	8½—	9
Stearic Acid, double pressed	lb.	9½—	9¾
Stearic Acid, triple pressed	lb.	10¼—	10½

All other prices remain quotably unchanged.

Naval Stores

All prices are f.o.b. New York unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Rosin B-D, bbl.	280 lb.	$5.40 —	5.45
Rosin E-I	280 lb.	5.50 —	5.55
Rosin K-N	280 lb.	6.15 —	6.90
Rosin W. G.-W. W.	280 lb.	7.00 —	7.25
Wood rosin, bbl.	280 lb.	6.25 —	.....
Spirits of turpentine	gal.	91½ —	.....
Wood turpentine, steam dist.	gal.	.89½ —	.....
Wood turpentine, dest. dist.	gal.	.88½ —	.....
Pine tar pitch, bbl.	200 lb.	..... —	6.00
Tar, kiln burned, bbl. (500 lb.)	bbl.	..... —	10.00
Retort tar, bbl.	500 lb.	—	9.00
Rosin oil, first run	gal.	.36 —	.....
Rosin oil, second run	gal.	.39 —	.....
Rosin oil, third run	gal.	.46 —	.....
Pine oil, steam dist., sp.gr., 0.930-0.940	gal.		$1.90
Pine oil, pure, dest. dist.	gal.		1.50
Pine tar oil, ref., sp.gr. 1.025-1.035	gal.		.46
Pine tar oil, crude, sp.gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.		.35
Pine tar oil, double ref., sp.gr. 0.965-0.990	gal.		.75
Pine tar, ref., thin, sp.gr., 1.080-1.960	gal.		.35
Turpentine, crude, sp. gr., 0.900-0.970	gal.		1.25
Hardwood oil, f.o.b. Mich., sp.gr., 0.960-0.990	gal.		.35
Pinewood creosote, ref.	gal.		.52

Fertilizers

Ammonium sulphate, bulk	100 lb.	$2.50 —	2.60
Blood, dried, f.o.b., N. Y.	unit	4.00	
Bone, 3 and 50, ground, raw	ton	30.00 —	32.00
Fish scrap, dom., dried, f.o.b. works	unit	3.10 —	3.20
Nitrate soda	100 lb.	2.37 —	2.40
Tankage, high grade, f.o.b. Chicago	unit	3.25 —	3.40
Phosphate rock, f.o.b. mines, Florida pebble, 68-72%	ton	5.50 —	7.00
Tennessee, 78-80%	ton	8.50 —	9.00
Potassium muriate, 80%	ton	34.00 —	37.00
Potassium sulphate	unit	1.00 —	.....

Crude Rubber

Quotations Unchanged as of Feb. 8.

Oils

VEGETABLE

The following prices are f.o.b. New York for carload lots.

Castor oil, No. 3, in bbls.	lb.	$0.10½ —	$0.10¾
Castor oil, AA, in bbls.	lb.	.11½ —	.12
China wood oil, in bbls. (f.o.b. Pac. coast)	lb.	.14 —	.14½
Coconut oil, Ceylon grade, in bbls.	lb.	.08½ —	.09
Coconut oil, Cochin grade, in bbls.	lb.	.09½ —	.10
Corn oil, crude, in bbls.	lb.	.08½ —	.09
Cottonseed oil, crude (f. o. b. mill)	lb.	.08¼ —	.08½
Cottonseed oil, summer yellow	lb.	.09½ —	.10
Cottonseed oil, winter yellow	lb.	.10¼ —	.10½
Linseed oil, raw, car lots (domestic)	gal.	.78 —	.79
Linseed oil, raw, tank cars (domestic)	gal.	.73 —	.74
Linseed oil, in 5-bbl lots (domestic)	gal.	.82 —	.84
Olive oil, denatured	gal.	1.10 —	1.12
Palm, Lagos	lb.	.07¼ —	.08
Palm, Niger	lb.	.06½ —	.06¾
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.08¼ —	.08½
Peanut oil, refined, in bbls.	lb.	.10½ —	.11
Rapeseed oil, refined in bbls.	gal.	.85 —	.86
Rapeseed oil, blown, in bbls.	gal.	.88 —	.89
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.09 —	.....
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.07¼ —	....

FISH

Light pressed menhaden	gal.	$0.45 —	....
Yellow bleached menhaden	gal.	.48 —	....
White bleached menhaden	gal.	.47 —	....
Blown menhaden	gal.	.57 —	....

Miscellaneous Materials

Prices Remain the Same as Feb. 8 Report

Ferro-Alloys

All f.o.b. Works

Ferrocarbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00 —	$225.00
Ferrochromium, per lb. of Cr contained, 6-8% carbon, carlots	lb.	11½—	....
Ferrochromium, per lb. of Cr contained, 4-6% carbon, carlots	lb.	12 —	....
Ferromanganese, 76-80% Mn, domestic	gross ton	59.00 —	60.00
Ferromanganese, 78-82% Mn, Foreign, c. i. f. Atlantic seaport	gross ton	58.00 —	59.00
Spiegeleisen, 18-22% Mn	gross ton	25.00 —	27.00
Ferromolybdenum, 50-60% Mo, per lb. of Mo	lb.	2.25 —	.....
Ferrosilicon, 10-15%	gross ton	38.00 —	40.00
Ferrosilicon, 50%	gross ton	54.00 —	55.00
Ferrosilicon, 75%	gross ton	115.00 —	120.00
Ferrotungsten, 70-80%, per lb. of contained W	lb.	.40 —	.45
Ferro-uranium, 35-50% of U, per lb. of U content	lb.	6.00 —	.....
Ferrovanadium, 30-40% per lb. of contained V	lb.	4.00 —	4.25

Ores and Semi-finished Products

All f.o.b. New York, Unless Otherwise Stated

Bauxite, 52% Al content	net ton	$8.00 —	$10.00
Chrome ore, Calif. concentrates, 50% min. Cr_2O_3	ton	21.00 —	22.00
Chrome ore, 50% Cr_2O_3, f.o.b. Atlantic seaboard	ton	21.00 —	22.00
Coke, foundry, f.o.b. ovens	net ton	3.50 —	3.75
Coke, furnace, f.o.b. ovens	net ton	2.75 —	3.00
Fluorspar, gravel, f.o.b. mines, New Mexico	net ton	12.00 —	.....
Fluorspar, standard, domestic washed gravel Kentucky and Illinois mines	net ton	20.00 —	22.00
Ilmenite, 52% TiO_2, per lb. ore	lb.	.01½—	.01½
Manganese ore, 50% Mn, c.i.f. Atlantic seaport	unit	.24 —	.....
Manganese ore, chemical (MnO_2)	net ton	55.00 —	60.00
Molybdenite, 85% MoS_2, per lb. of MoS_2, N. Y.	lb.	.48 —	.50
Monazite, per unit of ThO_2, c.i.f., Atlantic seaport	unit	27.00 —	.....
Pyrites, Spanish, fines, c.i.f., Atlantic seaport	unit	.12 —	.12
Pyrites, Spanish, furnace size, c.i.f. Atlantic seaport	unit	.13 —	.13
Pyrites, domestic, fines, f.o.b. mines, Ga.	unit	.11 —	.12
Rutile, 95% TiO_2 per lb. ore	lb.	.12 —	.....
Tungsten, scheelite, 60% WO_3 and over, per unit of WO_3 (nominal)	unit	2.50 —	2.75
Tungsten, wolframite, 60% WO_3 and over, per unit of WO_3, N. Y. C.	unit	2.75 —	3.00
Uranium ore (carnotite) per lb. of U_3O_8	lb.	1.25 —	1.75
Uranium oxide, 96% per lb. contained U_3O_8	lb.	2.25 —	2.50
Vanadium pentoxide, 99%	lb.	12.00 —	14.00
Vanadium ore, per lb. of V_2O_5 contained	lb.	1.00 —	.....
Zircon, washed, iron free, f.o.b. Pablo, Florida	lb.	.04½—	.13½

Non-Ferrous Metals

New York Markets

	Cents per Lb.
Copper, electrolytic	13.25
Aluminum, 98 to 99 per cent	19.00
Antimony, wholesale lots, Chinese and Japanese	4.45
Nickel, ordinary (ingot)	41.00
Nickel, electrolytic	44.00
Nickel, electrolytic, resale	32.00
Monel metal, shot and blocks	35.00
Monel metal, ingots	38.00
Monel metal, sheet bars	40.00
Tin, 5-ton lots, Straits	31.875
Lead, New York, spot	4.70
Lead, E. St. Louis, spot	4.375–4.40
Zinc, spot, New York	4.95
Zinc, spot, E. St. Louis	4.50

OTHER METALS

Silver (commercial)	oz.	$0.66¾
Cadmium	lb.	1.00–1.10
Bismuth (500 lb. lots)	lb.	2.00@2.10
Cobalt	lb.	3.00@3.25
Magnesium (f.o.b. Philadelphia)	lb.	1.25
Platinum	oz.	90.00@ 95.00
Iridium	oz.	170.00@190.00
Palladium	oz.	60.00
Mercury	75 lb.	49.00

FINISHED METAL PRODUCTS

	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	21.25
Copper bottoms	28.75
Copper rods	19.75
High brass wire	17.45
High brass rods	14.75
Low brass wire	18.75
Low brass rods	19.25
Brazed brass tubing	25.50
Brazed bronze tubing	30.50
Seamless copper tubing	21.25
Seamless high brass tubing	18.50

OLD METALS—The following are the dealers' purchasing prices in cents per pound:

	New York Current
Copper, heavy and crucible	10.25@10.75
Copper, heavy and wire	10.00@10.25
Copper, light and bottoms	7.75@ 8.25
Lead, heavy	3.60@ 3.85
Lead, tea	3.00@ 3.25
Brass, heavy	4.50@ 4.75
Brass, light	4.00@ 4.25
No. 1 yellow brass turnings	4.00@ 4.25
Zinc	2.25@ 2.50

Structural Material

The following base prices per 100 lb. are for structural shapes 3 in. by ¼ in. and larger, and plates ¼ in. and heavier, from jobbers' warehouses in the cities named:

	New York*	Cleveland	Chicago
Structural shapes	$2.63	$2.63	$2.63
Soft steel bars	2.53	2.53	2.53
Soft steel bar shapes	2.53	2.53	2.53
Soft steel bands	3.13	3.13	3.13
Plates, ¼ to 1 in. thick	2.63	2.63	2.63

*Add 15c per 100 lb. for trucking to Jersey City and 10c for delivery in New York and Brooklyn.

Industrial

Financial, Construction and Manufacturers' News

Construction and Operation

Arkansas

ASHDOWN—The new company being organized by A. D. Banks, Little Rock, Ark., and associates, to operate a cement mill in the White Cliffs section, has concluded negotiations with the Ashdown Chamber of Commerce for the construction of a road to the property and for other work incidental to the establishment of the plant. Construction will be commenced at once, and equipment orders placed. In addition to the cement mill the company will also establish a plant for the manufacture of fertilizer products and whiting. The new organization will operate with a capital of $1,000,000.

California

ALAMEDA—The Direct Steel Process Co., San José, Cal., with experimental plant at Alameda, has preliminary plans under way for the construction of a new steel-manufacturing plant in the vicinity of San Francisco, and is negotiating with the Chamber of Commerce at the latter place for a suitable site. H. Bardue, vice-president and general manager, is in charge.

TORRENCE—Officials of the John E. Thropp's Sons Co., Lewis St., Trenton, N. J., manufacturer of rubber mill machinery, etc., have acquired the local plant of the Hendrie Rubber Co., and will organize a new company under the name of the Hendrie Rubber Tire Co. to operate the Torrence works for the manufacture of automobile tires, tubes and other rubber products. The new company will have a capital of $200,000, and will equip the plant for an initial daily capacity of about 350 tires and 200 tubes. Thomas H. Thropp is president and general manager; John E. Thropp, secretary; and William Baker, treasurer. The last noted will take up a residence in southern California, and will be in charge of operations at the plant.

NAPA—The Pacific Portland Cement Co. will discontinue operations at its mills at Napa Junction, near Napa, and the plant will be dismantled. It is proposed to remove the machinery to a new mill site.

Connecticut

NEW MILFORD—The New England Lime Co., Danbury, Conn., has awarded a contract to the Berlin Bridge Co., Berlin, Conn., for the construction of three 1-story buildings at New Milford, to replace its works recently destroyed by fire, with loss approximating $125,000. The new buildings will be 30 x 300 ft., 40 x 200 ft. and 25 x 75 ft., and with machinery will cost about the amount of fire loss. A number of other buildings will be erected at a later date. E. C. Grinning is president.

DANBURY—Fire, Feb. 3, destroyed a portion of the plant of the Beaverbrook Paper Mills, Inc., with loss estimated at about $125,000, including equipment.

NEW HAVEN—The Seamless Rubber Co., Hallock Ave., manufacturer of small rubber goods, has awarded a contract to Sullivan & McKeown, New Haven, for the construction of its proposed 1-story and basement addition, 140 x 160 ft., with wing extension, 60 x 60 ft., estimated to cost about $100,000. It will be used for spraying and other branches of manufacture. R. W. Foote, 185 Church St., is architect.

Idaho

COEUR D'ALENE—Idaho Clays, Inc., recently organized with a capital of $500,000, is arranging for the erection of a new plant on local site for the manufacture of brick, sewer pipe, terra cotta and other burned clay products. The company is headed by Laurence A. Spear and William M. Colby, both of Spokane, Wash.

Kansas

WICHITA—The Derby Oil Co. has construction under way on a new local oil refinery, estimated to cost about $500,000, with machinery, and will place the plant in service at the earliest date possible.

Louisiana

MONROE—The Sterling Carbon Co., Sterlington, near Monroe, is planning for the rebuilding of the mechanical department at its works destroyed by fire, Jan. 11, with loss estimated at about $25,000.

AVONDALE—The Standard Oil Co. of Louisiana has acquired the local plant of the Export Oil Corp., totaling about 800 acres, with frontage on the Mississippi River, for a consideration said to be about $950,000. The plant comprises a number of buildings, pumping plant, pipe line, storage facilities approximating 790,000 bbl., and will be used by the new owner primarily for export trade.

Massachusetts

SPRINGFIELD—The Strathmore Paper Co. has commenced the erection of its proposed new plant addition at West Springfield, to be 2-story, brick and concrete, 25 x 65 ft. The Casper Ranger Construction Co., Holyoke, Mass., has the general contract.

Maryland

BALTIMORE—The Mineral Potash Co., 712 Equitable Bldg., is completing plans and will soon take bids for the erection of a new 1-story plant at Ilchester, Md., to be 50 x 150 ft., and estimated to cost about $50,000. Louis A. Hazard is president.

BALTIMORE—Gilpin, Langdon & Co., Inc., 300 West Lombard St., manufacturer of drugs, chemicals, etc., has filed plans for the erection of a 1-story factory, 65 x 211 ft., at Eagle and Smallwood Sts., estimated to cost about $40,000.

VIENNA—The Nanticoke Flour Mill, operated by R. H. Baumgartner, is planning for the immediate rebuilding of the portion of its plant, destroyed by fire, Jan. 26, with loss estimated at about $17,000.

BALTIMORE—The Water Board, City Hall, has authorized the immediate preparation of plans for the construction of a new filtration plant for the waterworks system at Montebello, comprising new settling basins, coagulating basins, filtration plant proper and filtered-water reservoirs, estimated to cost about $1,200,000. William A. Megraw is water engineer in charge.

Michigan

KALAMAZOO—The Kalamazoo Vegetable Parchment Co., has completed plans and will take bids early in March for the erection of a 2-story addition to its plant, 90 x 925 ft., estimated to cost about $400,000. It will consist of two complete machine units. Billingham & Cobb, Press Bldg., are architects. J. Kindleberger is president and general manager.

BAY CITY—The Wildman Rubber Co. is perfecting plans for the early completion of its new local plant, now in course of erection, to be used for the manufacture of tires and other rubber products. To provide sufficient funds for the project, the company has arranged for a stock issue of $5,000,000, and this will be used, in part, for buildings and equipment purchases. W. W. Wildman, formerly president of the Portage Rubber Co., is head of the company; C. R. Twynham is treasurer.

DETROIT—The Aetna Portland Cement Co., 412 Union Trust Bldg., has completed plans for the erection of the first unit of its new cement mill at Essexville, near Bay City, and will commence work at an early date. It is estimated to cost in excess of $500,000. Franklin R. Johnson is president, and O. J. Lingeman, secretary.

Missouri

JEFFERSON CITY—The Standard Crate & Filler Co., operating at the former local plant of the J. M. Hays Wood Products Co., has acquired property totaling about 50 acres as a site for a new plant for the manufacture of strawboard products. It will cost about $350,000 with machinery. Plans will be prepared at an early date. The company was organized recently with a capital of $350,000.

New Jersey

NEWARK—The Nickelsburg Brothers Co., Meadow St., manufacturer of leather, has filed plans for the erection of a 1-story addition, 50 x 100 ft., to cost about $12,000.

WOODSTOWN—The South Jersey Farmers' Exchange has tentative plans under consideration for the erection of a 1-story fertilizer works, 50 x 180 ft., to replace its plant recently destroyed by fire. A. B. Lippincott is in charge.

JERSEY CITY—Colgate & Co., 105 Hudson St., manufacturers of soaps, etc., have filed plans for the erection of an addition to their plant at 17-25 Grand St., to cost about $22,000.

New York

BOLIVAR—The Bolivar Refining Co. is planning for the erection of a new oil refinery on local site. An extensive oil storage plant will also be constructed. Charles A. Chapman is head.

OSWEGO—The local plant of the National Starch Co., of the Corn Products Refining Corp., 17 Battery Pl., New York, has been acquired by the Oswego Factories Corp., which will take possession on July 1. The new owner plans for the operation of the works.

BROOKLYN—Fire on Feb. 3 partly destroyed the three buildings at 61-65 Taaffe Pl., occupied by the Columbia Cement Co., Floradale Chemical Co. and the Eastern Bronze Wire Works, respectively, with loss estimated at close to $25,000, divided among the different companies.

Ohio

FOSTORIA—The Bellevue Rubber Co., Bellevue, O., H. B Skinner, president, is planning for extensions and improvements in its 2-story and basement plant at Fostoria.

Pennsylvania

LOCK HAVEN—Fire on Feb. 1 destroyed the main building at the plant of the American Aniline Products Co., with loss estimated at about $200,000.

MOUNT UNION—The plant of the Mount Union Tanning & Extract Co. has been acquired by Calvin Greene and associates, who will operate the property in the future. The factory heretofore has been devoted to the manufacture of sole leather.

HAZELHURST—Fire on Jan. 27 destroyed a portion of the local plant of the Interstate Window Glass Co., with loss estimated at about $125,000.

MOUNT HOLLY SPRINGS—Llewllyn A. Marr, 176 Federal St., Boston, Mass., and E. J McDonnell, associated paper manufacturers, have acquired the local plant of the Mount Holly Paper Mills Co. at a receiver's sale for a consideration stated as $55,000. The new owners plan to place the mill in service at an early date, giving employment to about 125 operatives.

Tennessee

CHATTANOOGA—The Crane Enameling Co., recently organized as a subsidiary of the Crane Co., 835 South Michigan Ave., Chicago, Ill., with capital of $1,500,000, has taken possession of the local plants of the Mutual Enameling Co. and the Cahill Iron Works, and will operate these plants for the manufacture of high-grade enamel ware. The new factory of the Mutual company in the Alton Park section will be used as the main plant unit, and the Cahill works on Chestnut St. will be used as a branch. When operating full the two plants will give employment to about 600 operatives. R. T. Crane, Jr., Chicago, is president.

Texas

HOUSTON—The Switzer-Parke Co., 105 Paige St., recently organized with a capital of $30,000, has awarded a contract for the erection of a new plant, totaling about 11,000 sq.ft. of floor space, to be equipped as an electroplating and enamel-baking works. It is planned to commence production at an early date. Willard M. Parke is president, and Homer E. Switzer, secretary-treasurer.

TERRELL—Fire on Jan. 27 destroyed a portion of the plant of the Terrell Cotton Oil & Refining Co., with loss estimated at close to $40,000.

West Virginia

BLUEFIELD—The Tri-State Chemical Co., Box 46, recently organized, is planning for the establishment of a local plant for the manufacture of special chemical powders for fire-extinguishing service. Edward Palmer is manager.

New Companies

THE ATLANTIC CHEMICAL MFG. CO., Atlantic City, N. J., has been incorporated with a capital of $50,000, to manufacture chemicals and chemical byproducts. The incorporators are John A. G. Iden, Fred P. Steckel and Irving P. Parsons, 33 Real Estate Bldg., Atlantic City.

THE IRONIZED YEAST CO., Atlanta, Ga., has been incorporated with a capital of $300,000, to manufacture yeast and kindred products. The incorporators are W. P. Bloodworth, Mark Bolding and R. G. Stephens, all of Atlanta.

THE MARCO CHEMICAL CO., 501-2 Genesee Bank Bldg., Flint, Mich., has been incorporated with a capital of $10,000, to manufacture chemicals, alkalis and affiliated products. The incorporators are Clyde Newman, Lee L. Martin and H. Martin.

THE EASTERN BRICK CO., New York, N. Y., has been incorporated under Delaware laws with capital of $2,000,000, to manufacture brick, tile and other burned clay products. The company is represented by the United States Corporation Co., 65 Cedar St., New York.

THE OSWEGO FALLS CORP., Fulton, N. Y., has been incorporated with a capital of $2,500,000, to manufacture pulp and paper products. The company will comprise a merger of the Oswego Falls Pulp & Paper Co., Fulton; the Skaneateles Paper Co., Skaneateles, N. Y.; and the Sealright Co., in this same district. The incorporators are H. L. Paddock, F. G. Weeks and C. W. Tooke. Headquarters will be at the plant of the Oswego Falls Pulp & Paper Co., Fulton.

THE HORMONE CHEMICAL CORP., East Orange, N. J., has been incorporated with a capital of $50,000, to manufacture chemicals and chemical byproducts. The incorporators are Arthur L. Walsh, Joseph F. McCoy and Harold L. Lyman, 331 Main St., East Orange.

THE JOSE OIL CO., Los Angeles, Cal., has been incorporated with a capital of $200,000, to manufacture petroleum products. The incorporators are H. A. Bordeen, J. Paul Getty and Russell Avery. The company is represented by Anderson & Anderson, 1112 Black Bldg., Los Angeles.

E. W. JEFFRESS, INC., Detroit, Mich., has been incorporated with a capital of $10,000, to manufacture chemicals and affiliated products. The incorporators are J. G. Hamblen, Jr., E. W. and M. M. Jeffress, 1350 Jefferson Ave., East, Detroit.

THE ABBOTT INK CO., Room 1400, 69 West Washington St., Chicago, Ill., has been incorporated with a capital of $9,000, to manufacture inks and kindred specialties. The incorporators are Thuriow W. Brewer, Nicholas F. Roeder and Francis B. Regan.

THE FARMERS' FERTILIZER CO., Sumter, S. C., has been incorporated with a capital of $10,000, to manufacture fertilizer products. H. J. Harby is president; H. W. Harby, vice-president; and J. H. Guthrie, secretary, all of Sumter.

THE INGERSOLL PRODUCTS CO., Newark N. J., has been incorporated with 500 shares of stock, no par value, to manufacture oil compounds, etc. The incorporators are J. S. Leichliter, H. T. Maloney and Palmer Bradner, Kinney Bldg., Newark.

THE EDDYLITE SPARK PLUG CO., Buffalo, N. Y. has been incorporated with a capital of $100,000, to manufacture porcelain spark plugs and affiliated products. The incorporators are W. F. Feser, L. J. and C. B. Eddy. The company is represented by J. H. Ryan, attorney, Olean, N. Y.

THE INTERNATIONAL CHEMICAL PRODUCTS CO., San Fernando, Cal., has been incorporated with a capital of $250,000, to manufacture chemicals and chemical byproducts. The incorporators are H. J. Poppelman, Arthur G. and Bernard A. Munn, all of San Fernando.

THE DAMASCUS STEEL PRODUCTS CORP., 1500 Fourteenth Ave., Rockford, Ill., has been incorporated with a capital of $50,000, to manufacture steel specialties. The incorporators are C. F. Maitland, C. P. Twomey and J. R. Hughes.

THE SUNFLOWER OIL CO., Shreveport, La., has been incorporated with a capital of $120,000, to manufacture petroleum products. A. W. Baird, Sr., is president; John B. Hutchinson, vice-president; and A. W. Baird, Jr., secretary and treasurer, all of Shreveport.

THE LA SALLE PAPER CO., South Bend, Ind., has been incorporated with a capital of $250,000, to manufacture paper and pulp products. The incorporators are E. O. and Claude E. Nicely, and John G. Yeagley, all of South Bend.

THE GOODCHILD GLASS MFG. CO., Hawthorne, N. J., has been incorporated with a capital of 2,500 shares of stock, no par value, to manufacture glassware products. The incorporators are Walter Goodchild, Walter Hohenhausen and Harry Grundy, 177 Washington Ave., Hawthorne.

THE PORT UNION BRASS FOUNDRY CO., New York, N. Y., has been incorporated with a capital of $30,000, to manufacture brass, bronze and other metal castings. The incorporators are H. V. Bebarfald, B. F. Vineburg and P. E. Uhr. The company is represented by Manken Bros., 206 Broadway, New York.

THE MARYLAND SMELTING & REFINING CO., INC., 23 West Antietam St., Hagerstown, Md., has been incorporated with a capital of $35,000, to manufacture refined metals, operate a smelting works, etc. The incorporators are Henry H. Keedy, Jr., Leon R. Yourtee and John D. Keith.

THE AMERICAN LEATHER GOODS CO., Newark, N. J., has been incorporated with a capital of $100,000, to manufacture leather products. The incorporators are Abraham Danzig, Edward Faragasso and John Parlante. The company is represented by Philip J. Schotland, 9 Clinton St., Newark.

THE NATIONAL INK CO., Baltimore, Md., has been incorporated under Delaware laws with capital of $100,000, to manufacture inks, chemicals and kindred products. The incorporators are James L. Bell, Harry D. Howell and Harry A. Kendall, Baltimore. The company is represented by the Colonial Charter Co., Ford Bldg., Wilmington, Del.

THE SUMMER RUBBER CO., Boston, Mass., has been incorporated with a capital of $5,000, to manufacture rubber products. John Woolf is president, and Victor Miller, 53 Strathmore Road, Brookline, Mass., treasurer.

THE ARCHER PHOSPHATE DEVELOPMENT CO., Archer, Fla., has been incorporated with a capital of $75,000, to manufacture phosphate and kindred products for fertilizer and other service. W. F. Walker is president; S. G. Moyers, vice-president; and E. N. Morrow, secretary and treasurer, all of Archer.

THE HART LEATHER FINISH CO., 1046 West Division St., Chicago, Ill., has been incorporated with a capital of $10,000, to manufacture finishes and compounds for leather and kindred products. The incorporators are James M. Hart, William B. Carroll and Edward S. Cummings.

THE SMITHFIELD OIL CO., Wilmington, Del., has been incorporated under state laws with capital of $100,000, to manufacture petroleum products. The company is represented by the Capital Trust Co. of Delaware, Dover, Del.

ZIEGEL, EISMAN & CO., Newark, N. J., has been incorporated with a capital of $1,000,000, to manufacture leather products. The incorporators are M. and H. Seymour Eisman, and Leo Goldsmith, 99 Frelinghuysen Ave., Newark.

THE FRANKFORD PAPER BOX CO., Philadelphia, Pa., is being organized by William J. Zimmerman, Jr., George E. Beck and J. Edward Linck, to manufacture paper products. Application for a state charter will be made at once. The company is represented by R. P. Frank Maxwell, 1919 East Chelten St., Philadelphia.

THE TRAVIS COTTONSEED PRODUCTS CO., Austin, Tex., has been incorporated with a capital of $50,000, to manufacture cottonseed oils. The incorporators are E. H. Perry, D. G. Reed and Oscar Robinson, all of Austin.

ZURA, INC., 608 South Dearborn St., Chicago, Ill., has been incorporated with a capital of $50,000, to manufacture chemicals and affiliated products. The incorporators are Joseph B. Duncan, E. C. Auld and William B. Ziff.

THE UTAH SHALE PROCESS CORP., Denver, Col., has been incorporated under Delaware laws with capital of $1,000,000, to manufacture coal-tar products and affiliated specialties. The incorporators are Frederick M. Browning, Denver; William S. Pitts, and David C. Dodge, New York. The company is represented by the Colonial Charter Co, Ford Bldg., Wilmington, Del.

THE MUTUAL OIL PRODUCTS CO., Newark, N. J., has been incorporated with a capital of $100,000, to manufacture refined oil products. The incorporators are Harvey C. Harrison, Clarence L. Powell and Robert Rogers, 17 Margaretta St., Newark.

THE PINEVILLE PAINT & VARNISH CO., Pineville, Ky., has been incorporated with a capital of $20,000, to manufacture paints, varnishes, etc. The incorporators are H. M. Ernst, W. N. Payne and W. L. Long, all of Pineville.

Capital Increases, Etc.

THE INDIAHOMA REFINING CO., East St. Louis, Ill., operating a local oil refinery and with similar plant at Okmulgee, Okla., has disposed of a bond issue of $1,750,000, the proceeds to be used for financing, general operations, etc. Elmer E. Schock is president.

THE AMERICAN ART CLAY CO., Indianapolis, Ind., has filed notice of dissolution under state laws.

THE WISCONSIN CHEMICAL CO., Detroit, Mich., capitalized at $100,000, has filed notice of dissolution.

THE HOOKER ELECTROCHEMICAL CO., Niagara Falls, N. Y., has filed notice of a mortgage on its property taken by the Equitable Trust Co., New York, N. Y., totaling $12,500,000.

THE GENERAL LINSEED OIL CO., 1637 West Roosevelt St., Chicago, Ill., has filed notice of change of name to the General Paint & Varnish Co., at the same time increasing its capital from $10,000 to $50,000.

A. Parker Nevin has been appointed receiver for the EL SALVADOR SILVER MINES CO., 11 Pine St., New York, N. Y., operating properties in San Salvador. Edward D. Dowling is president.

THE COLUMBUS FOUNDRY CO., Columbus, Ga., and the W. L. LEMLY FOUNDRY CO., Bessemer, Ala., have been merged under the latter name, and the plant of the first noted company will be removed to Bessemer.

THE MAINE PULP & PAPER CO., D. S. Morgan Bldg., Buffalo, N. Y., with pulp and paper mills in Maine, has filed a voluntary petition in bankruptcy, listing liabilities of $420,391.96, and assets of $454,021.09. Andrew Krieger is president.

Stockholders of the KELLEY TIRE & RUBBER CO., New Haven, Conn., manufacturer of tires and other rubber goods, with local plant, are arranging for a reorganization, abolishing the receivership under which operations have been conducted for some time.

The flour mill property of the C. A. GAMBRILL MFG. CO., Ellicott City, Md., will be offered for sale by the trustees in bankruptcy, Herman A. Tingley and John B. H. Dunn, 110 Commerce St., Baltimore, Md., on Feb. 20.

Manufacturers' Catalogs

THE QUIGLEY FURNACE SPECIALTIES CO., New York, has recently issued Bull. 51 on the method of applying successful boiler setting patches. Another bulletin presents information, with illustrations, regarding refractory linings and the use of Hytempite in power plant work, as well as its uses in connection with Carbosand for baffles, patching boiler settings, etc. Pages 18 and 19 give some information on the uses of Insulbrix and show comparative heat losses of uninsulated and insulated walls. This company also calls attention to Bull. 52, describing the use of Hytempite in making one-piece baffles of refractory concrete. This bulletin is well illustrated and tells an interesting story of the experience of a large Brooklyn concern.

THE NORTON CO., Worcester, Mass., has issued two new bulletins: one on "Metal Polishing" and the other on "Factors Affecting Grinding Wheel Selection."

THE CAREY CO., Pittsburgh, Pa., has issued a circular describing its newly patented carboy inclinator, which is claimed to be a much more economical way of handling acids and other chemicals, when received in carboys.

ROBERT L. STILLSON CO., New York has published an attractive book on "Outspinning the Spider, the Story of Wire and Wire Rope," by John Kimberly Mumford. It tells the history of wire-rope making in this country from the beginning of the industry in 1840, and relates the romance of the Brooklyn Bridge; of the wire rope barrage laid down in the English Channel during the late war; and other interesting engineering achievements.

INGERSOLL-RAND CO., New York, has issued a catalog on "Steam Condensing Plants" which is a reprint of Paul Bancel's paper read before the Baltimore Section of the American Society of Mechanical Engineers, May 16, 1921.

WILLIAMS TOOL CORP., Erie, Pa., calls attention to its latest booklet entitled "Don't Let It Happen to You." This booklet was written for the man who owns or

operates a power pipe machine, and represents an endeavor on the company's part to educate and instruct all operators of power pipe machines for better threads and greater production. Copies will gladly be sent on request.

THE CUTLER-HAMMER MFG. CO., Milwaukee, has issued a new bulletin, No. 2039, covering the New Thomas Calorimeter, which records total heating values of gas graphically.

THE GENERAL ENGINEERING CO., Salt Lake City, Utah, has issued a new metallurgical bulletin describing its facilities for investigations in ore treatment. The pamphlet is illustrated with representative mills, design and construction by the company. It contains also considerable general information on metal statistics, cost of mill operations, cost of steam and electric power, etc. The company has made an unusual and successful effort to produce a bulletin of exceptional value.

THE AMERICAN STEAM GAUGE & VALVE MFG. CO., Boston, Mass., in an 8-page folder illustrates and describes the new American recording thermometer, which has been designed after years of experimental work and field tests. These instruments are designed to record accurate temperatures and to meet every industrial need and can be furnished for any desired temperature range up to 1,000 deg. F.

BEACH-RUSS CO., New York City announces a new 4-page bulletin, No. 27, on Rotary Pumps.

THE ABBE ENGINEERING CO., New York City has issued Bull. 18 on its products, which include pebble mills, ball mills, tube mills, pulverizing machinery, bolting cloth, rotary cutters, disintegrators, mixers, etc.

THE GOULDS MFG. CO., Seneca Falls, N. Y., is distributing Bull. 123 descriptive of the newest addition to its pump line—the Goulds steam turbine-driven centrifugal pump.

THE DURIRON CO., INC., Dayton, O., calls attention to Bulletin 127, illustrating and describing the Duriron-Merco lubricated plug cock, which should be of interest where corrosion must be controlled in pipe lines. In Bulletin 126-A this company treats sanitary drain pipe and fittings.

THE INDUSTRIAL WORKS, Bay City, Mich., has published Catalog 113, illustrating and describing the Type BC "Industrial crawling tractor crane, which has a capacity of 20,000 lb. and can be equipped to handle a hook and block, grab bucket, drag-scraper bucket, wood grapple, electric-lifting magnet shovel dipper, and pile driver leads with drop hammer. This crane should prove useful to road contractors, lumber and coal dealers, gravel, sand and stone producers, foundries, railroad reclamation and storage yards, and moderate-size manufacturing plants.

THE ATLAS VALVE CO., Newark, N. J., has just published Catalog 21, on Atlas, Ideal and Victor reducing valves, pump governors, pressure regulators, hot water tank regulators, control valves and damper regulators. This 20-page catalog illustrates, describes and lists all sizes and gives prices. A copy will be sent free on request.

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis., calls attention to Bulletin 1108, on Power Transformers. This attractive 32-page booklet illustrates and describes power transformers.

STROMBERG ELECTRIC CO., Chicago, Ill., has issued a bulletin describing its process timing and signaling instruments. This instrument has been developed as an accurate means of automatically operating a signal at the end of a predetermined time, to announce the completion of a process or operation, and has a very broad field of application.

THE UNION MINING CO., INC., Mount Savage, Md., has issued Catalog H, on Firebrick. It contains 150 pages, 4 x 6¾ in., and describes the company's products and also gives general information.

SKINNER, SHERMAN & ESSELEN, Boston, Mass., have issued a booklet entitled "Mr. Banker, Meet Old Man Chemistry," by James H. Collins. It is an interesting booklet, which has been published in the endeavor to give publicity to chemical matters. Copies will be sent on request.

THE VACUUM OIL CO., New York, has issued two educational publications: One on "Oil Engines" and the other on "Stationary Steam Engines." In the first-mentioned booklet the principle is described as well as the construction, operation, cooling, fuel, methods of lubrication, lubricating oil and deposits. The second booklet treats reciprocating steam engineers and boiler plant and steam production. Interested individuals will be furnished copies on request.

THE OILGEAR CO., Milwaukee, Wis., announces the publication of Bull. 2, on Oilgear variable speed hydraulic power transmissions, and Bull. 6, on the Oilgear Control Pump.

THE CUTTER CO., Philadelphia, Pa., has issued a bulletin on U-re-lite, which is an I-T-E circuit breaker inclosed in a specially constructed steel case from the front of which projects a convenient operating handle.

THE BRISTOL CO., Waterbury, Conn., has published Catalog 1501, descriptive of its round chart recording electrical instruments, including voltmeters, ammeters and wattmeters, which can be furnished in the strip chart type.

New Publications

NEW BUREAU OF MINES PUBLICATIONS: Eleventh Annual Report of the Director of the Bureau of Mines to the Secretary of the Interior for the fiscal year ended June 30, 1922; Bull. 187, Treatment of the Tungsten Ores of Boulder County, Col., by J. P. Bonardi and J. C. Williams; Tech. Paper 248, Gas Masks for Gases Met in Fighting Fires, by Arno C. Fieldner, Sidney H. Katz and Selwyne P. Kinney; Tech. Paper 249, The Determination of Oxides of Nitrogen, by V. C. Allison, W. L. Parker and C. W. Jones; Tech. Paper 284, Coal and Coke Mixtures as Water-Gas Generator Fuel, by W. W. Odell.

NEW BUREAU OF STANDARDS PUBLICATIONS: Circular 38, The Testing of Rubber Goods; Circular 113, Structure and Related Properties of Metals; Circular 115, Recommended Specifications for Pneumatic Tires, Solid Tires and Inner Tubes; Circular 117, Recommended Specification for Interior Varnish; Circular 118, Recommended Specification for Limestone, Quicklime and Hydrated Lime for Use in the Manufacture of Glass; Sci. Paper 419, The Production of Liquid Air on a Laboratory Scale, by J. W. Cook; Sci. Paper 420, Specific Volume of Liquid Ammonia, by C. S. Cragoe and D. R. Harper; Tech. Paper 193, Design of Atmospheric Gas Burners, by Walter M. Berry, I. V. Brumbaugh, G. F. Moulton and G. B. Shawn; Tech. Paper 196, High Fire Porcelain Glazes, by H. H. Sortwell; Tech. Paper 197, Cementing Qualities of the Calcium Aluminates, by P. H. Bates; Tech. Paper 199, Method for Precision Test of Large Capacity Scales, by C. A. Briggs and E. D. Gordon.

NEW U. S. GEOLOGICAL SURVEY PUBLICATIONS: I: 8, Antimony in 1920, by Frank C. Schrader (Mineral Resources of the U. S., 1920, Part I), published Oct. 27, 1921; I: 9, Lead in 1920, by C. E. Siebenthal and A. Stoll (Mineral Resources of the U. S., 1920, Part I), published Oct. 14, 1921; I: 10, Secondary Metals in 1920, by J. P. Dunlop (Mineral Resources of the U. S., 1920, Part I), published Nov. 11, 1921; I: 12, Gold, Silver, Copper and Lead in South Dakota and Wyoming in 1920, by C. W. Henderson (Mineral Resources of the U. S., 1920, Part I), published Nov. 3, 1921; I: 13, Gold, Silver, Copper, Lead and Zinc in California and Oregon in 1920, by Charles G. Yale (Mineral Resources of the U. S., 1920, Part I), published Nov. 25, 1921; I: 15, Zinc in 1920, by C. E. Siebenthal and A. Stoll (Mineral Resources of the U. S., 1920, Part I), published Dec. 19, 1921; I: 23, Iron Ore, Pig Iron and Steel in 1919, by Ernest F. Burchard (Mineral Resources of the U. S., 1919, Part I), published Oct. 14, 1921; I: 24, Zinc in 1919, by C. E. Siebenthal and A. Stoll (Mineral Resources of the U. S., 1919, Part I), published Oct. 13, 1921; I: 25, Gold and Silver in 1919, by J. P. Dunlop (Mineral Resources of the U. S., 1919, Part I), published Oct. 31, 1921; I: 26, Cobalt, Molybdenum, Nickel, Tantalum, Titanium, Tungsten, Radium, Uranium and Vanadium in 1919, by Frank L. Hess (Mineral Resources of the U. S., 1919, Part I), published Nov. 10, 1921; II: 13, Potash in 1920, by M. R. Nourse (Mineral Resources of the U. S., 1920, Part II), published Oct. 4, 1921; II: 14, Sodium Compounds in 1920, by Roger C. Wells (Mineral Resources of the U. S., 1920, Part II), published Sept. 30, 1921; II: 15, Slate in 1920, by G. F. Loughlin and A. T. Coons (Mineral Resources of the U. S., 1920, Part II), published Oct. 12, 1921; II: 16, Carbon Black Produced From Natural Gas in 1920, by E. G. Sievers (Mineral Resources of the U. S., 1920, Part II), published Oct. 13, 1921; II: 17, Silica in 1920, by L. M. Beach (Mineral Resources of the U. S., 1920, Part II), published Oct. 11, 1921; II: 18, Feldspar in 1920, by L. M. Beach (Mineral Resources of the U. S., 1920, Part II), published Oct. 29, 1921; II: 19, Abrasive Materials in 1920, by L. M. Beach and A. T. Coons (Mineral Resources of the U. S., 1920, Part II), published Oct. 28, 1921; II: 20, Mineral Waters in 1920, by W. D. Collins (Mineral Resources of the U. S., 1920, Part II), published Oct. 29, 1921; II: 21, Sand and Gravel in 1920, by L. M. Beach (Mineral Resources of the U. S., 1920, Part II), published Nov. 5, 1921; II: 22, Lime in 1920, by G. F. Loughlin and A. T. Coons (Mineral Resources of the U. S., 1920, Part II), published Nov. 3, 1921; II: 23, Barytes and Barium Products in 1920, by George W. Stose (Mineral Resources of the U. S., 1920, Part II), published Dec. 6, 1921; II: 29, Abrasive Materials in 1919, by L. M. Beach and A. T. Coons (Mineral Resources of the U. S., 1919, Part II), published Sept. 16, 1921; II: 31, Lime in 1919, by G. F. Loughlin and A. T. Coons (Mineral Resources of the U. S., 1919, Part II), published Oct. 6, 1921; II: 32, Stone in 1919, by G. F. Loughlin and A. T. Coons (Mineral Resources of the U. S., 1919, Part II), published Oct. 18, 1921; II: 34, Natural-Gas Gasoline in 1919, by E. G. Sievers (Mineral Resources of the U. S., 1919, Part II), published Dec. 7, 1921.

THE UNIVERSITY OF ILLINOIS has issued Bulletin 125, on "The Distribution of the Forms of Sulphur in the Coal Bed," by H. F. Yancey and Thomas Fraser.

THE NATIONAL RESEARCH COUNCIL has issued pamphlet No. 15, on "Researches on Modern Brisant Nitro Explosives," by C. F. vanDuin and B. C. Roeters vanLennep, and No. 23, on "American Research Chemicals," by Clarence J. West.

THE HERCULES POWDER CO., Wilmington, Del., has reprinted in pamphlet form N. S. Greensfelder's article on "Explosives' Part in China Making," which appeared in the *Hercules Mixer* for January, 1922.

"REZISTAL STEEL" is the title of a pamphlet by Charles Morris which is being issued with the compliments of the Crucible Steel Co. of America, New York.

Coming Meetings and Events

AMERICAN CERAMIC SOCIETY will hold its twenty-fourth annual meeting at St. Louis, Feb. 27 to March 3, 1922.

AMERICAN CHEMICAL SOCIETY will hold its spring meeting at Birmingham, Ala., April 4 to 7, 1922.

AMERICAN ELECTROCHEMICAL SOCIETY will hold its spring meeting in Baltimore, April 27, 28 and 29, 1922. Headquarters will be at the Emerson Hotel.

AMERICAN FOUNDRYMEN'S ASSOCIATION will hold its next convention and exhibit at Rochester, N. Y., during the week of June 5, 1922. Meetings will be held in the spring instead of in the fall as heretofore.

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS will hold its spring meeting in New York the week of Feb. 20, 1922.

AMERICAN SOCIETY FOR STEEL TREATING, will hold a sectional meeting, Friday, March 3, at the Hotel McAlpin, New York City.

AMERICAN SOCIETY FOR TESTING MATERIALS will hold its twenty-fifth annual meeting June 26 to July 1, at Atlantic City, N. J. Headquarters will be at the Chalfonte-Haddon Hall Hotel.

INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY will hold a meeting at Lyons, France, June 27 to 30.

IRON AND STEEL INSTITUTE (British) will hold its annual meeting on May 4 and 5 at the House of the Institution of Civil Engineers, Great George St., S. W., 1, London.

NEW JERSEY CHEMICAL SOCIETY holds a meeting at Stetters Restaurant, 842 Broad St., Newark, N. J., the second Monday of every month.

NORTHWEST MINING ASSOCIATION is holding a convention in the Chamber of Commerce Bldg., Spokane, Wash., Feb. 14 to 18.

STAMFORD CHEMICAL SOCIETY, Stamford, Conn., holds a meeting in the lecture room of the local high school on the fourth Monday of each month, except June, July, August and September.

The following meetings are scheduled to be held in Rumford Hall, the Chemists' Club, New York: March 10—American Chemical Society, Nichols Medal; March 24—Society of Chemical Industry, regular meeting; April 21—Society of Chemical Industry (in charge), American Electrochemical Society, Société de Chimie Industrielle, American Chemical Society, joint meeting; May 5—American Chemical Society, regular meeting; May 12—Société de Chimie Industrielle (in charge), American Chemical Society, Society of Chemical Industry, American Electrochemical Society, joint meeting; May 19—Society of Chemical Industry, regular meeting; June 9—American Chemical Society, regular meeting.